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Performance Analysis of OFDM with Different Modulation Schemes

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Abstract: OFDM (Orthogonal Frequency Division Multiplexing) is a most frequently developing technology in modern mobile communication. OFDM is a parallel transmission scheme, where a high rate serial data stream is split up into a set of low – rate sub streams each of which is modulated on a separate subcarrier. Increasing the number of parallel transmission reduces the data rate that each individual carrier must convey and that lengthens the symbol period. However, in OFDM, no frequency diversity is exploited to improve BER performance. Today's OFDM systems attempt to overcome this limitation by application of channel coding and interleaving, which requires a reduction in throughput. OFDM uses different type of modulation schemes to improve BER performance. In this paper we compared OFDM system by using 4-QAM, 16-QAM, 64-QAM and QPSK modulation schemes over multi-path fading channels at the cost of small increase in complexity.

Keywords: OFDM, BER, Parallel to Serial, Serial to Parallel Converter

I. INTRODUCTION OF OFDM

OFDM is a multicarrier transmission technique, which divides the available spectrum into many carriers, each one being modulated by a low rate data stream. OFDM is similar to the FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels, that are then allocated to users. However, the OFDM uses the spectrum much more efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to each another, preventing interference between the closely spaced carriers.

COFDM is the same as the OFDM except that forward error correction is applied to the signal before transmission [4]. This is used to overcome errors in the transmission due to lost carriers from frequency selective fading, channel noise and other propagation effects. In FDMA each user is typically allocated a single channel, which is used to transmit all the user information. The allocated bandwidth is made wider than the minimum amount required to prevent channels from interfering with one another. This extra bandwidth is to allow for signals from neighboring channels to be filtered out, and to allow for any drift in the center frequency of the transmitter or receiver. In a typical system up to 50% of the total spectrum is wasted due to the extra spacing between channels. This problem becomes worse as the channel bandwidth becomes narrower, and the frequency band increases. Most digital phone systems use vocoders to compress the digitized speech. This allows for an increased system capacity due to a reduction in the bandwidth required for each user. However, simple FDMA does not handle such narrow bandwidths very efficiently.

TDMA partly overcomes this problem by using wider bandwidth channels, which are used by several users. Multiple users access the same channel by transmitting in their data in time slots. Thus, many low data rate users can be combined together to transmit in a single channel which has a bandwidth sufficient so that the spectrum can be used efficiently. There are however, two main problems with TDMA. There is an overhead associated with the changeover between users due to time slotting on the channel. A change over time must be allocated to allow for any tolerance in the start time of each user, due to propagation delay variations and synchronization errors. This limits the number of users that can be sent efficiently in each channel. In addition, the symbol rate of each channel is high (as the channel handles the information from multiple users) resulting in problems with multipath delay spread. OFDM overcomes most of the problems with both FDMA and TDMA. OFDM splits the available bandwidth into many narrow band channels typically 100 – 8000. The carriers for each channel are made orthogonal to one another, allowing them to be spaced very close together, with no overhead as in the FDMA example. Because of this there is no great need for users to be time multiplex as in TDMA, thus there is no over head associated with switching between users.

The orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. Due to this, the spectrum of each carrier has a null at the centre frequency of each of the other carriers in the system. This results in no interference between the carriers, allowing then to be spaced as close as theoretically possible. This overcomes the problem of overhead carrier spacing required in FDMA. Each carrier in an OFDM signal has a very narrow bandwidth, thus the resulting symbol rate is low. This results in the signal having a high tolerance to multipath delay spread, as the delay spread must be very long to cause significant inter-symbol interference.

II. SYSTEM MODEL OF OFDM

An OFDM system has the three main parts: transmitter, channel and receiver. The basic components of an OFDM transmitter are channel coding, QPSK modulator, sub-carrier assignment i.e. OFDM baseband modulator and single carrier modulator shown in Figure 1. Since OFDM is preferably used for the uplink in a multiuser environment, low-order modulation such as QPSK with Gray mapping is preferred. However, basically high-order modulation (64-QAM) can also be employed. The sub-carrier assignment can be fixed or dynamic. In practice, in order to increase the system robustness a dynamic assignment of sub-carriers (i.e., frequency hopping) for each user is preferable. For pulse shaping, rectangular shaping is usually used which results for K users in an OFDM-type signal at the receiver side. In summary, where only one sub-carrier is assigned to a user, the modulator for the user could be a single-carrier modulator [4]. If several carriers are used for a given terminal station, the modulator will be a multi-carrier (OFDM) modulator.

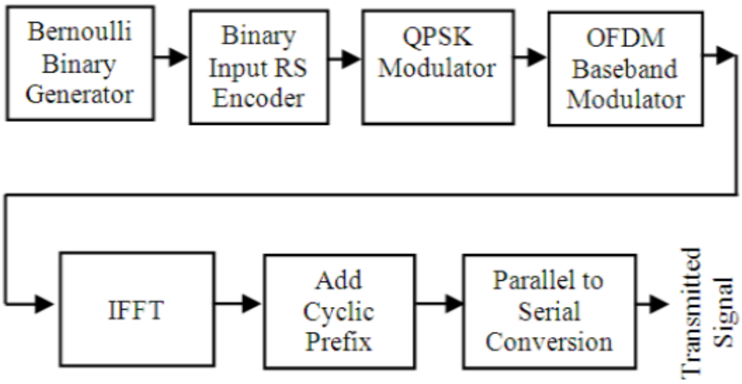

Figure 1. OFDM Transmitter.

Parallel to serial converter uses the Unbuffer block which unbuffers an Mi-by-N frame-based input into a 1-by-N sample-based output. That is, inputs are unbuffered row-wise so that each matrix row becomes an independent time-sample in the output. The rate at which the block receives inputs is generally less than the rate at which the block produces outputs. In the unbuffer first the data is stored at a memory location in serial form and then comes out from other side of the unbuffer as a parallel data. The out coming data depends upon the first in first out method. Then the parallel data converted into serial form by using this unbuffer block. So simply unbuffer block acts as a temporary memory and gives output data one digit at a time to convert it serially.

At the receiver the main components are the OFDM baseband demodulator, QPSK demapping, channel decoder (with soft decisions) are used for receiving the transmitted signal and then processed this signal to get the original transmitted data. But this received signal is not same as that of the transmitted signal. The received signal is the approximation of transmitted signal by hard decision methods. For this purpose OFDM baseband demodulator and QPSK demodulation are used. For error detection and correction purpose we used channel decoder. In this model we used Reed – Solomon detector for correction of errors.

Similarly, In serial to parallel converter we uses the Buffer block redistributes the input samples to a new frame size, larger or smaller than the input frame size. Buffering to a larger frame size yields an output with a slower frame rate than the input, as illustrated below for scalar input.

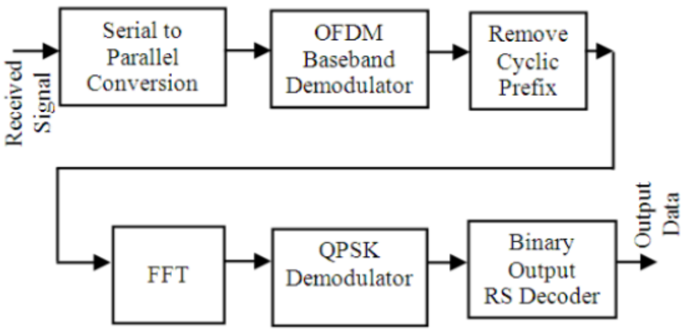

Figure 2. OFDM Receiver.

OFDM overcomes most of the problems with both FDMA and TDMA. OFDM divides the available bandwidth into many narrow band channels. The carriers for each channel are made orthogonal to each other, allowing them to be

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spaced very close together. The orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. Due to this, the spectrum of each carrier has a null at the centre frequency of each of the other carriers in the system. This results in no interference between the carriers, allowing then to be spaced as close as theoretically possible. This overcomes the problem of overhead carrier spacing required in FDMA. Each carrier in an OFDM signal has a very narrow bandwidth (i.e. 1 kHz), thus the resulting symbol rate is low. This will give the signal a high tolerance to Multipath delay spread, because the delay spread must be very long to cause significant inter-symbol interference [5].

III. OFDM PERFORMANCE ANALYSIS

OFDM performance analysis presented in this section is based on computer simulations. The basic scenario of our simulation is represented by the OFDM transmission system performing through multipath fading and AWGN transmission channel, at sample time (16e-5)/44 and 44 samples per frame. The encoder of OFDM system uses Binary-Input RS Encoder block which creates a Reed- Solomon code with message length 11 and codeword length 15. Modulate or mapped the input signal using the quaternary phase shift keying method, the symbols can be either binary-demapped or Gray-demapped. Similarly, the Binary-Output RS Decoder block recovers a binary message vector from a binary Reed-Solomon codeword vector. For proper decoding, the parameter values in this block should match those in the corresponding Binary-Input RS Encoder block. The simulation results of OFDM system is shown below:

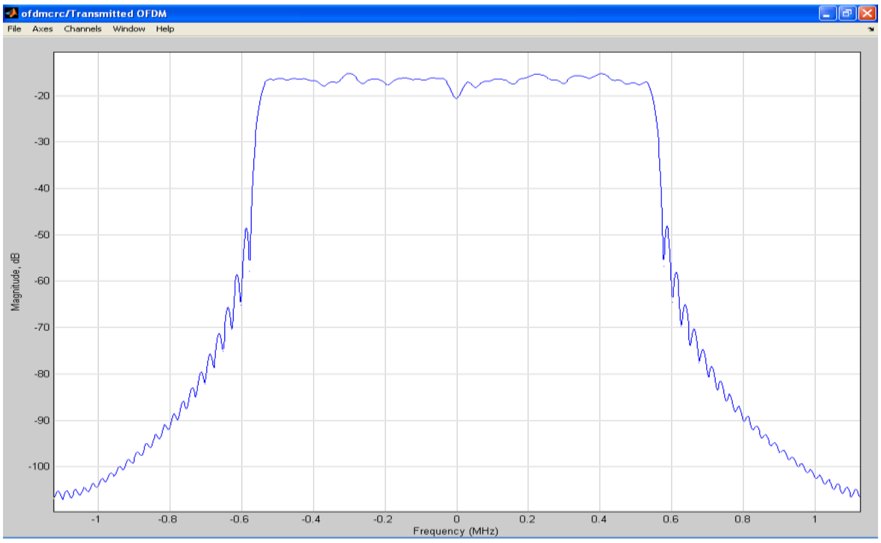

Fig. 3. OFDM Transmitted Signal.

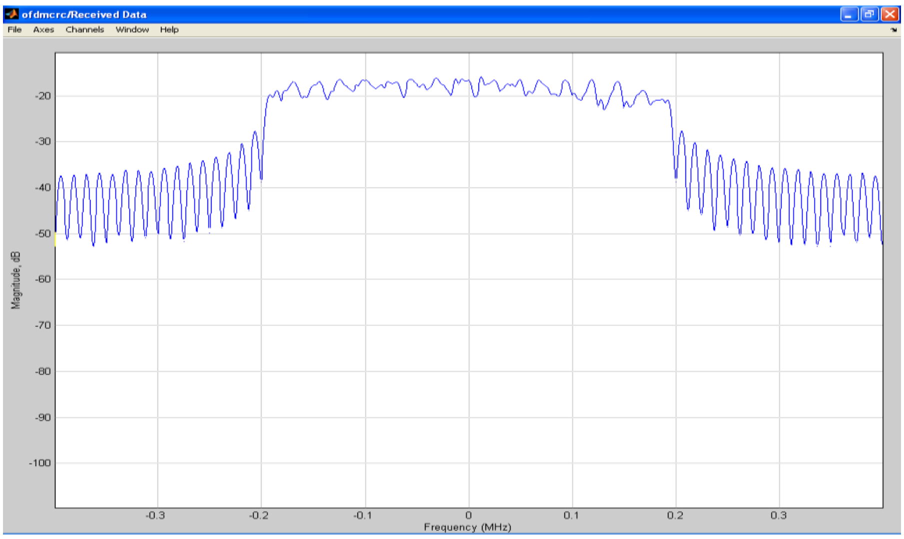

Fig. 4. OFDM Received Signal.

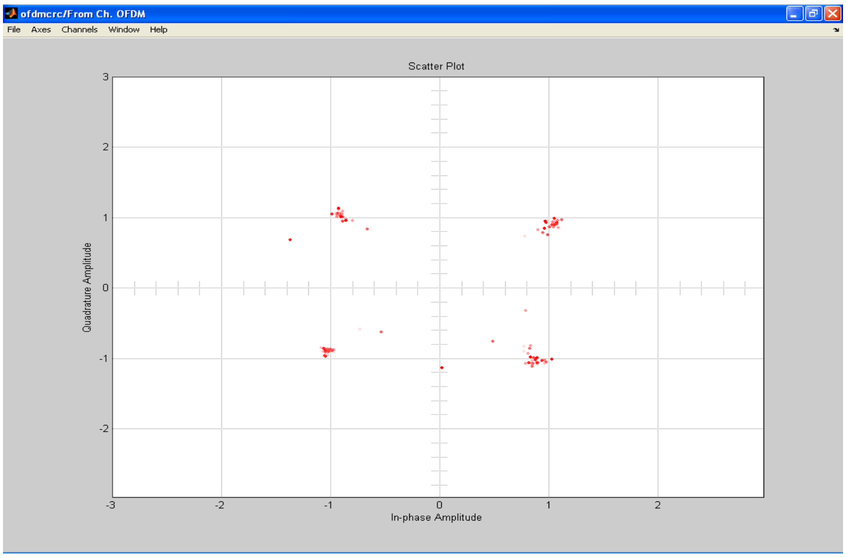

Fig. 5. Scatter Plot of OFDM Received Signal by using QPSK Modulation.

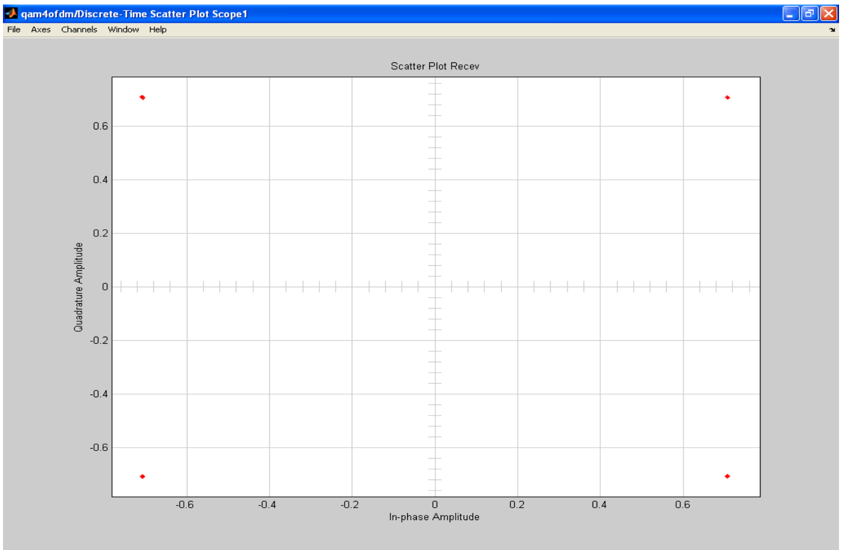

Fig. 6. Scatter Plot of OFDM Received Signal by using 4 – QAM Modulation.

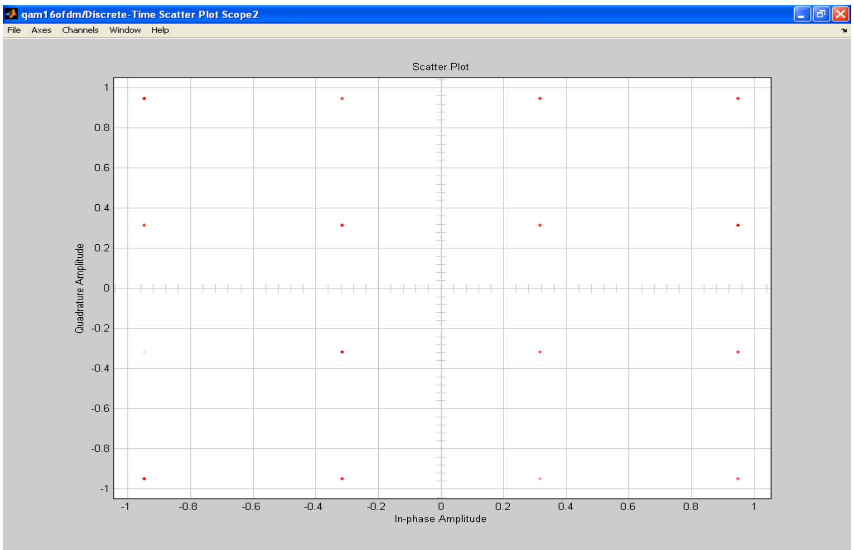

Fig. 7. Scatter Plot of OFDM Received Signal by using 16 – QAM Modulation.

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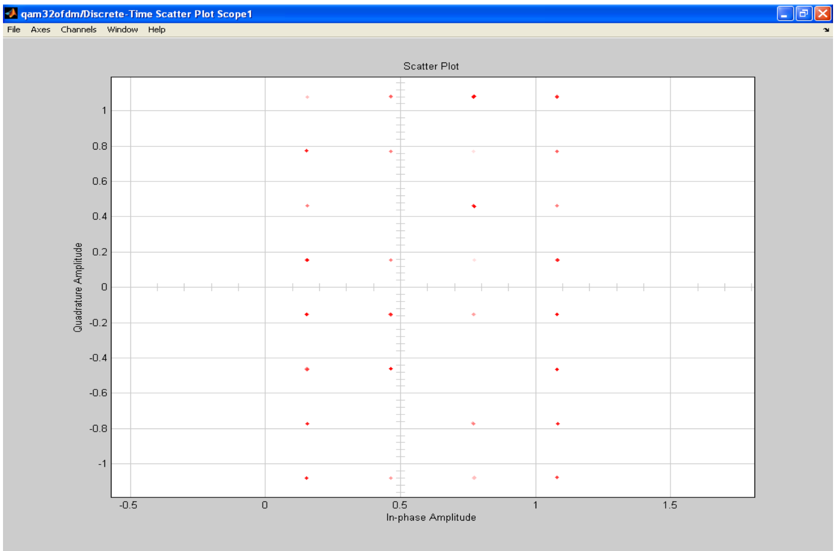

Fig 8. Scatter Plot of OFDM Received Signal by using 32 – QAM Modulation.

Fig. 6 shows the OFDM transmitted signal to the channel. This signal is passed through the multipath fading and additive white Gaussian noise channel. After passing this signal from channel we get the OFDM received signal as shown in Fig. 7 which is full of distortions but this distortion is less as compared in the case of CDMA system. The scatter plot is used to reveal the modulation characteristics, such as pulse shaping or channel distortions of the signal. Fig. 8 shows the scatter plot of OFDM received signal by using QPSK modulation. The scatter plot illustrates the effect of fading on the signal constellation. Similarly, Fig. 9 shows the scatter plot of OFDM received signal by using 4 – QAM modulation. Fig. 10 and Fig. 11 shows the scatter plot of OFDM received signal by using 16 – QAM and 64 – QAM modulations. By comparing these scatter plot figures we get that 64 – QAM modulation is best suitable for OFDM system [6]. In the OFDM system the received signal has more fading effects as compared to OFDM transmitted signal which results in more errors in OFDM system. But due to the use of Reed – Solomon encoder and decoder in OFDM system which acts as an error check code the BER of OFDM is decreased[7]. By using QPSK modulation scheme the distortion in the received signal is very high so the BER is very high. But if we use QAM modulation scheme the distortion is less and the BER is less than QPSK modulation scheme. As we increased the modulation index of the QAM the BER is decreased. This effect is shown in following Table 1.

Table 1. BER of OFDM with Different Modulation Schemes

Sr. No.	Modulation Scheme	Total Number of Bits	Error Bits	Bit Error rate
1.	4 – QAM	191808	143902	0.7502
2.	16 – QAM	190656	178683	0.9372
3.	32 – QAM	189888	183937	0.9686
4.	QPSK	550000	274700	0.4996

Table 1. Comparison of Modulation Schemes in OFDM So we get that from these 64 – QAM modulation scheme is very suitable for OFDM system because the transmission rate is very high and the BER is very low then other modulation schemes at same bandwidth usage. So a large number of users can efficiently use OFDM system by 64 – QAM modulation.

IV. CONCLUSION

The transmission bandwidth of the OFDM system by using different modulation schemes is approximately same but the number of user in 64 – QAM OFDM system is more than other modulation schemes. Because each user uses a very small portion of available bandwidth. But in a transmission system main concern is on efficient transmission i.e. number of error or distortion is less. So 64 – QAM modulated OFDM system is more efficient because it has less BER and less multipath fading effects as compare to other OFDM system. We conclude that 64- QAM modulated OFDM system achieves better BER results than QPSK and other modulated OFDM systems for the same bandwidth efficiency.

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