Simulink Model of OFDM Using 64-Qam with Different Combination of Channels

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Abstract: ***In this technical paper A MATLAB SIMULINK MODEL is designed to investigate Orthogonal Frequency Division Multiplexing (OFDM) communication systems through different mode of channels. This model is valuable fr future researchers simulating systems that are too theoretically complex to analyze. The paper details the analysis of a generic OFDM system. An analytical OFDM system using 64-QAM SIMULINK MODEL used to study Packet Loss, Bit Loss and Total Bits counted and effect on bit rate by using different types of channels and their different types of combination between transmitter and receiver. This technical paper plays a prominent role in the selection of good quality channel with minimum loss of information with high transmission rate.***

Keywords: OFDM, Packet Los, QAM (Quadrature amplitude modulation), CP(cyclic prefix), ISI, ICI, AWGM, Dispersive channel, Fading channel, IDFT, Bit Loss, Total Bit Counter, European Telecommunications Standards Institute (ETSI) for Digital Audio Broadcasting (DAB), Asynchronous Digital Subscriber Line (ADSL), Wireless LAN (IEEE 802.11), Digital Video Broadcast (DVB), WiMAX (IEEE 802.16), and others.

1. Introduction

The evolution of OFDM can be divided into three parts. There are consists of Frequency Division Multiplexing (FDM), Multicarrier Communication (MC) and Orthogonal Frequency Division Multiplexing. The objective of this model is to develop and explore a simulink model using 64-QAM (64-QAM rate 2/3, 2K and 1/32 guard interval). As we know that by increasing Orthogonality the data rate is decreases because of synchronization problem. When we used 16 QAM modulation the rate of transmission is low as compared to 64 QAM modulation technique but it have one drawback that its Orthogonality is less as compared to 64 QAM modulation scheme. Modulation technique with different combination of channels (AWGN, Dispersive, AWGN+ Dispersive, and none) between transmitter and receiver and to study Packet Loss, Bit Loss and Total Bits counted and effect on bit rate.

2. Orthogonality

Two signals are orthogonal if their dot product is zero. That is, if you take two signals multiply them together and if their integral over an interval is zero, then two signals are orthogonal in that interval. Mathematically, suppose we have a set of signals Ψ then,

$$\int_a^{a+T} \Psi_p(t)\,\Psi_q^*(t) = \begin{cases} K & \text{for } p = q \\ 0 & \text{for } p \neq q \end{cases}$$

The signals are orthogonal if the integral value is zero over the interval [a,a+T], where T is the symbol period. This way of transmitting information helps in handling the effects of multipath propagation efficiently. OFDM supports various modulations techniques like BPSK, QAM, and QPSK etc. In a classical parallel data system, the total signal frequency band is divided into N no overlapping frequency sub channels. Each sub channel is modulated with a separate symbol and then the N sub channels are frequency-multiplexed. I used 64 QAM Modulation to increase orthogonality however transmission rate is reduces as we know that 64-QAM has following properties ,rate 2/3, 2K and 1/32 guard interval. In 64 QAM transmission rate is 0.67 while in 16 QAM it is 0.75 hence transmission rate is decreases while Orthogonality increases.

3. General block diagram of OFDM System

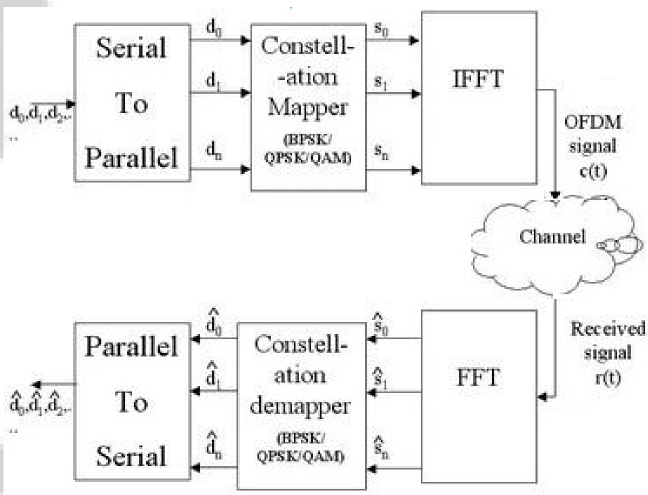

Figure 1: Block diagram of OFDM system

4. Spectrum of OFDM

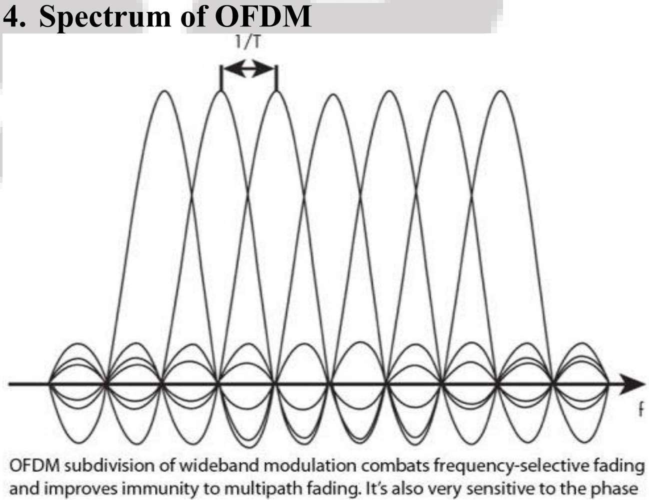

Figure 2: Spectrum of OFDM signal

5. Orthogonal Frequency Division Multiplexing

Orthogonal Frequency Division Multiplexing (OFDM) is simply defined as a form of multi-carrier modulation where the carrier spacing is carefully selected so that each sub-carrier is orthogonal to the other sub-carriers. Orthogonality can be achieved by carefully selecting the sub-carrier frequencies. One of the ways is to select sub-carrier frequencies such that they are harmonics to each other.

Delay spread: Another effect that affects digital transmission is that the signal coming from different paths has different time delays depending on the length of path. A consequence of that is memory of channel which cause interference between symbol received (ISI).

Synchronisation: One of the crucial problems in the receiver is to sample the incoming signal correctly. If the wrong sequence of samples is processed, the Fast Fourier Transform shall not correctly recover the received data on the carriers. The problem is more embarrassing when the receiver is switched on. There is therefore a need for acquiring timing lock. If the signal transmitted is really time domain periodic, as required for the FFT to be correctly applied, then the effect of the time displacement is to modify the phase of all carriers by a known amount. This is due to the time shift theorem in convolution transform theory.

Statement of Problem: The problem of using OFDM technique is orthogonality and transmission rate and makes it useful for multi carrier (MC) transmission technology. This is largely depend on modulation technique we are using in OFDM system. One of the crucial problems in the receiver is to sample the incoming signal correctly. If the wrong sequence of samples is processed, the Fast Fourier Transform shall not correctly recover the received data on the carriers. The problem is more embarrassing when the receiver is switched on. There is therefore a need for acquiring timing lock. But in this technical paper we are using only QAM modulation technique. We introduced four type of medium between transmitter and receiver that is AWGN channel, Dispersive channel, AWGN plus Dispersive channel, and none channel. During each configuration of OFDM communication system with different channel note down the packet loss, bit loss, and total number of transmitting bits. After each experiment compare the performance of each system and obtained best one for future use. A brief study of OFDM using 64 QAM simulink model is very useful to overcome the problems of ISI, ICI and Orthogonality. This paper presents the responses of OFDM system using 64 QAM with mode of channels.

6. Simulink Model of OFDM with 64 QAM

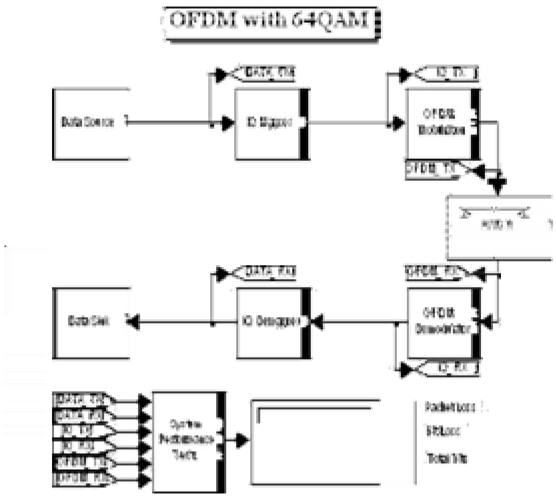

Figure 3: Simulink model of OFDM using 64-QAM with AWGN channel

This is the simulink model of OFDM with AWGN channel .Here we can see that a counter is used to count number of bits transmitted and number of bits los ses .

7. Result of Simulink Model

Here we are generating four cases for different channels between transmitter and receiver. The result of each syst em is shown with each step and the spectrum of transmitting signal and 64 QAM orthogonal.

Case-1 Transmitting spectrum of OFDM 64 QAM when using AWGN channel

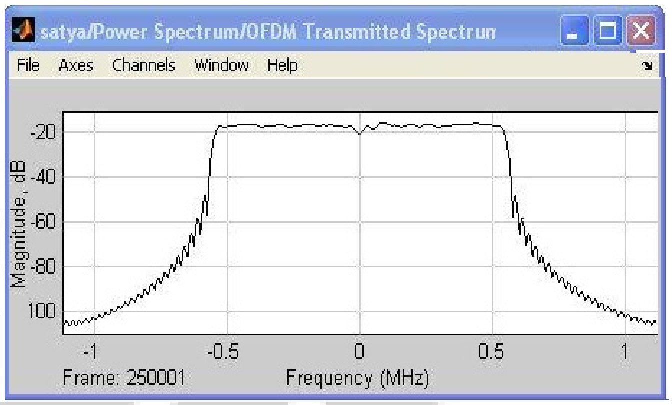

Figure 4 (a): Graph showing T_X Spectrum when using AWGN channel

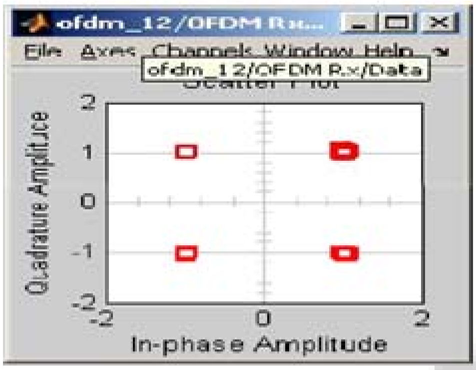

Figure 4 (b): Graph showing T_X Spectrum when using AWGN channel

Here we can see that the response is saturated with the passage of time and finally its look like ideal response of OFDM using 64 QAM simulink model. However practically this is not possible to obtain an Ideal response. The data rate is moderate with high degree of orthogonality. From fig.4 (a) the spectrum of transmitting data varies with frequency of transmission. This is the response of OFDM system using AWGN channel with 64 QAM modulation techniques.

Case-2 When using Dispersive channel:

The RX data and pilot tone constellations are now:

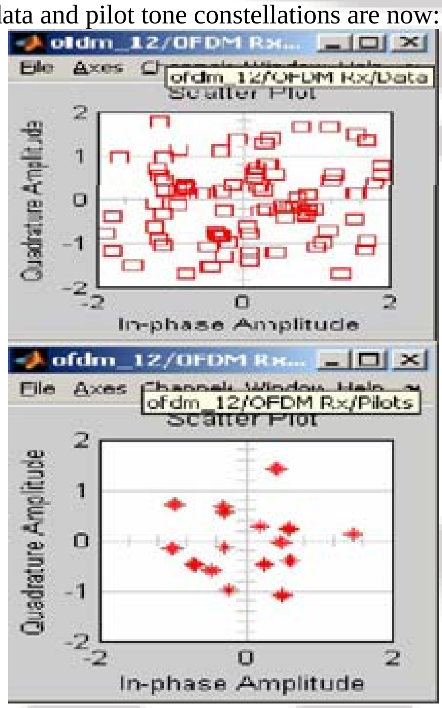

Figure 5 (a): Transmitting spectrum and R_X data with pilot constellation.

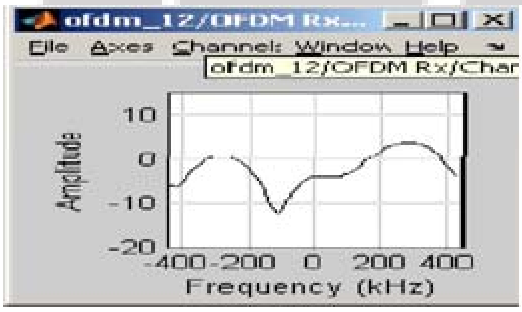

Figure 5 (b): Transmitting spectrum and R_X data with pilot constellation

The spectrum now looks like fully disturbed and it takes some time for ideal response and good quality response of Orthogonality. This is the response of OFDM when using dispersive channel. It's quite different then previous one used AWGN channel. Similarly count the number of bits transmitting and number of bits losses during transmission.

Case-3.The channel between transmitter and receiver is AWGN plus Dispersive channel

The RX data and pilot constellations will looks as follows:

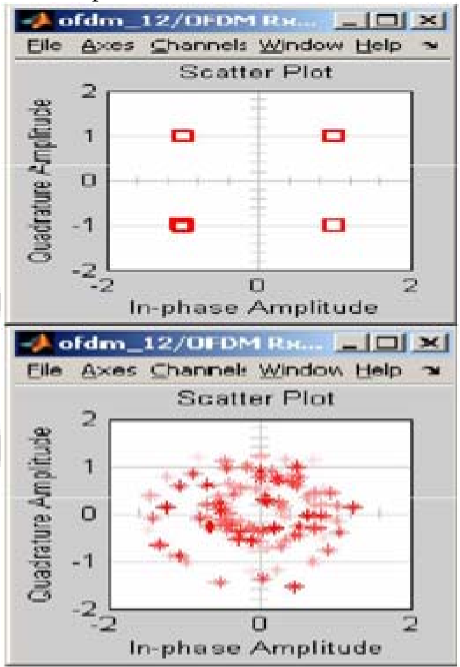

Figure 6 (a): Response of OFDM when using Fading channel

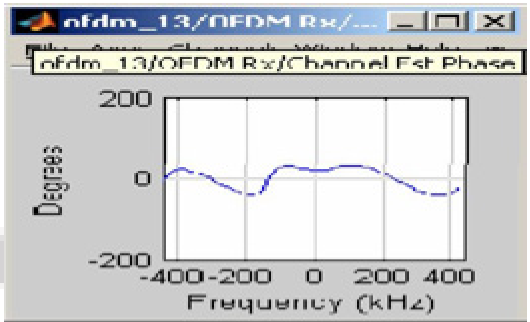

Figure 6(b): Response of OFDM when using Fading channel

Good quality response with some delay and QAM pilot tones plot now looks like circular moving around the centre. Here OFDM frequency becomes flat with time. Count down the total number of bits transmitted and losses during the transmission.

Case-4 None channel Ideal response with variation of carrier wave:

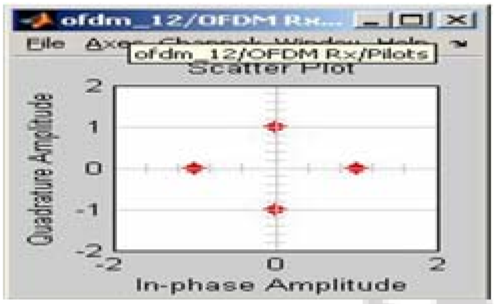

Figure 7(a): Graph shows Ideal pilot tones cancellation response

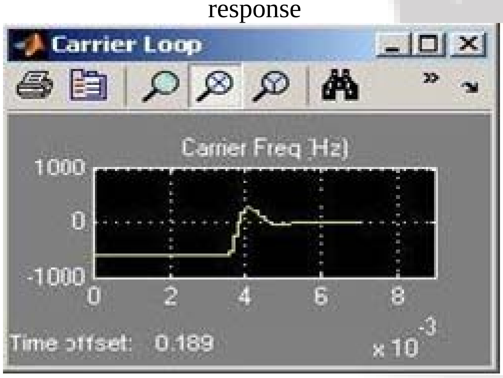

Figure 7 (b): OFDM Spectrum with none channel between T_X and R_X with Carrier loop graph

8. Limitations

a) **Synchronization:** One of the crucial problems in the receiver is to sample the incoming signal correctly. If the wrong sequence of samples is processed, the Fast Fourier Transform shall not correctly recover the received data on the carriers.

b) **Orthogonality:** We know that several carriers are actually advantageous whenever they are mathematically orthogonal. So carriers Orthogonality is a constraint that can leads to a wrong operation of OFDM systems if not respected. The Orthogonality is provided by IFFT.

9. Applications

For developing different applications we need some kind of sequences:

1. Measure of bit loss per symbol transmission.
2. Measure of rate of transmission.
3. Measure of ISI and ICI with different mode of transmission.

On the basis of above information this model is very useful for 3G, Digital Video Broadcasting, and High speed LAN network and in HDSL.

10. Future Improvements

OFDM Using 64 QAM Synchronization model is very useful in digital video broadcasting and in Multi Carrier CDMA (MC-CDMA).Since the transmission rate high so it can also useful in forthcoming 4G technology. HDSL: High bit rate Digital Subscriber Line.

11. Conclusion

At the time of reception, it is very important to distinguish the starting point of FFT to avoid wrong demodulation. And so synchronization has to be precise. It explains the use of special symbols (pilot) for synchronization in transmission. Hardware design of Transmitter and receiver is important because of high peak to average ratio which causes distortions if dynamic range of amplifiers and converters is not high enough. OFDM is very sensitive to carrier frequency offsets. Such offsets are mainly the cause of receiver local oscillators' instability and Doppler Effect when mobile is moving.

References

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