A Review Paper on Synchronization Techniques of OFDM

Pradeep Kumar
Department of Electronics and Communication Engineering
World Institute of Technology, Sohna-Gurugram, Affiliated to M.D.U Rohtak, India

Abstract— FDMA, TDMA and CDMA are the well known multiplexing techniques used in wireless communication systems. While working with the wireless systems using these techniques various problems encountered are (1) multi-path fading (2) time dispersion which lead to inter symbol interference (ISI) (3) lower bit rate capacity (4) requirement of larger transmit power for high bit rate and (5) less spectral efficiency. In a typical terrestrial broadcasting, the transmitted signal arrives at the receiver using various paths of different lengths. Since multiple versions of the signal interfere with each other, it becomes difficult to extract the original information. The use of orthogonal frequency division multiplexing (OFDM) technique provides better solution for the above mentioned problems. OFDM technique distributes the data over a large number of carriers that are spaced apart at precise frequencies. This spacing provides the "orthogonality", which prevents the demodulator from seeing frequencies other than their own.
Key words: OFDM

I. Introduction

In a basic communication system, the data are modulated onto a single carrier frequency. The available bandwidth is then totally occupied by each symbol. This kind of system can lead to inter-symbol-interference (ISI) in case of frequency selective channel. The basic idea of OFDM is to divide the available spectrum into several orthogonal sub channels so that each narrowband sub channel experiences almost flat fading. Orthogonal frequency division multiplexing (OFDM) is becoming the chosen modulation technique for wireless communications. OFDM can provide large data rates with sufficient robustness to radio channel impairments. Many research centers in the world have specialized teams working in the optimization of OFDM systems. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-carriers are transmitted in parallel. These carriers divide the available transmission bandwidth. The separation of the sub- carriers is such that there is a very compact spectral utilization. With OFDM, it is possible to have overlapping sub channels in the frequency domain, thus increasing the transmission rate. The attraction of OFDM is mainly because of its way of handling the multipath interference at the receiver. Multipath phenomenon generates two effects (a) Frequency selective fading and (b) Intersymbol interference

(ISI). Hence OFDM is a combination of modulation and multiplexing. Multiplexing generally refers to Independent signals, those produced by different sources.

II. Importance of Orthogonality

The main concept in OFDM is orthogonality of the sub-carriers. The "orthogonal" part of the OFDM name indicates that there is a precise mathematical relationship between the frequencies of the carriers in the system. It is possible to arrange the carriers in an OFDM Signal so that the sidebands of the individual carriers overlap and the signals can still be received without adjacent carriers interference. In order to do this the carriers must be mathematically orthogonal. The Carriers are linearly independent (i.e. orthogonal) if the carrier spacing is a multiple of 1/Ts. Where, Ts is the symbol duration. The orthogonality among the carriers can be maintained if the OFDM signal is defined by using Fourier transform procedures. The OFDM system transmits a large number of narrowband carriers, which are closely spaced. Note that at the central frequency of the each sub channel there is no crosstalk from other sub channels.

III. OFDM Model

Illustrates the baseband, discrete-time OFDM system model we investigate. The complex data symbols are modulated by means of an inverse discrete Fourier transform (IDFT) on N-parallel subcarriers. The resulting OFDM symbol is serially transmitted over a discrete time channel, whose impulse response we assume is shorter than L samples. At the receiver, the data are retrieved by means of a discrete Fourier transform (DFT).

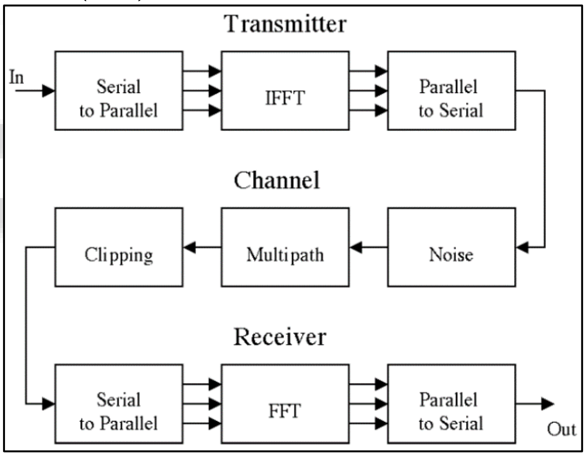


Fig. 1: Block Diagram of OFDM Model

An accepted means of avoiding intersymbol interference (ISI) and preserving orthogonality between subcarriers is to copy the last L samples of the body of the OFDM symbol (N samples long) and append them as a preamble—the cyclic prefix—to form the complete OFDM symbol . The effective length of the OFDM symbol as transmitted is this cyclic prefix plus the body (L+N samples long). The insertion of a cyclic prefix can be shown to result in an equivalent parallel orthogonal channel structure that allows for simple channel estimation and equalization. In spite of the loss of transmission power and bandwidth associated with the cyclic prefix, these properties generally motivate its use. In the following analysis, we assume that the channel is non dispersive and that the transmitted signal s(k) is only affected by complex additive white Gaussian noise (AWGN) n(k). We will, however, evaluate our estimator's performance for both the AWGN channel and a time-dispersive channel

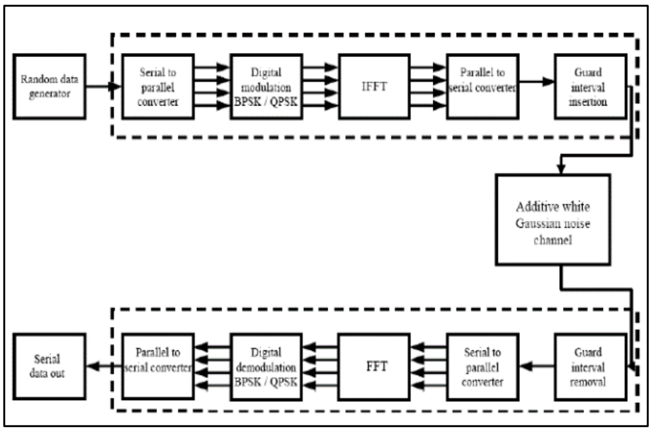


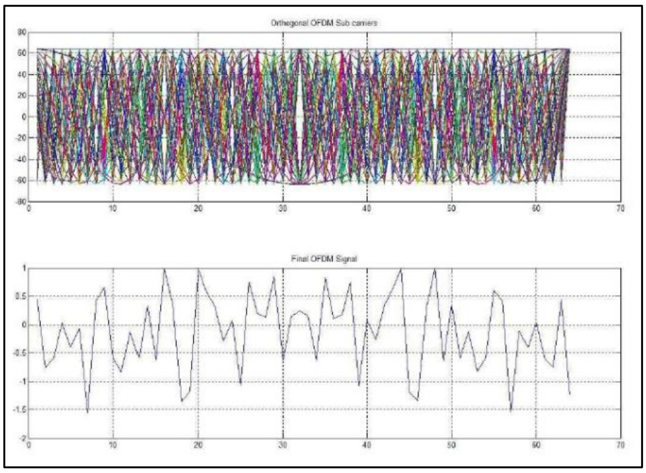
Fig. 2: Working Model of OFDM for Simulation

Random data generator Serial to parallel converter Digital modulation BPSK / QPSK IFFT Parallel to serial converter Guard interval insertion Additive white Gaussian noise channel

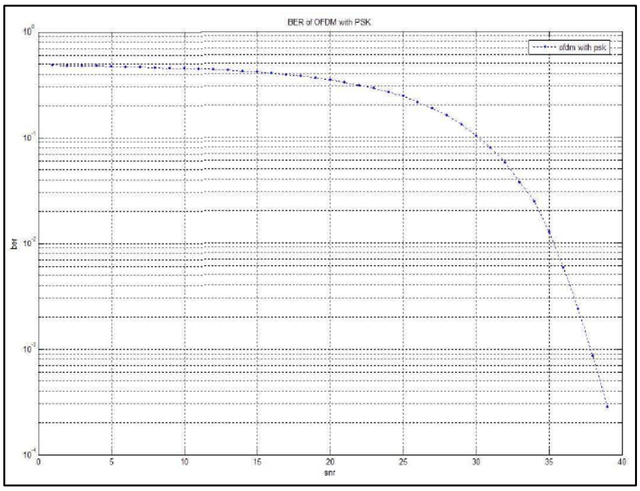
Guard interval removal Serial to parallel converter Parallel to serial converter Digital demodulation BPSK / QPSK Serial data out FFT Fig.-OFDM model used for simulation It shows the basic block diagram of OFDM transmitter and receiver used for simulation. OFDM is generated by choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned data to be transmitted. The required amplitude and phase of the carrier is then calculated based on the modulation scheme (typically BPSK, QPSK, or QAM). For example, if we have to transmit incoming 8 bit digital data, we have to choose 8 different carrier signals, which are orthogonal to each other. Each carrier is assigned to a different bit and its amplitude and phase are chosen according to modulation 39 scheme used. The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform.

IV. SIMULATION & RESULTS

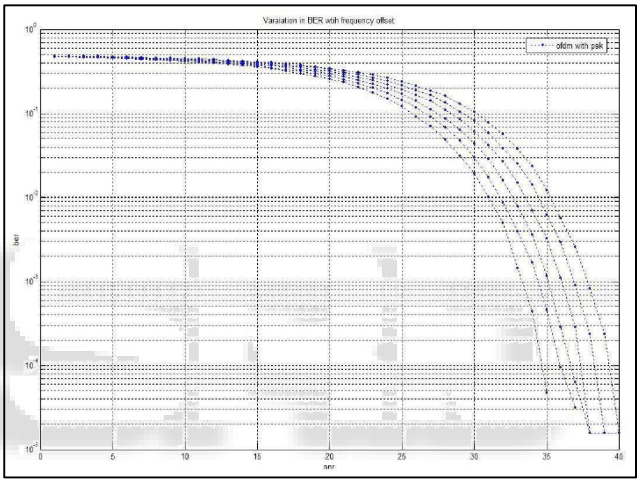
A. OFDM with 64 sub channels, simple OFDM symbol



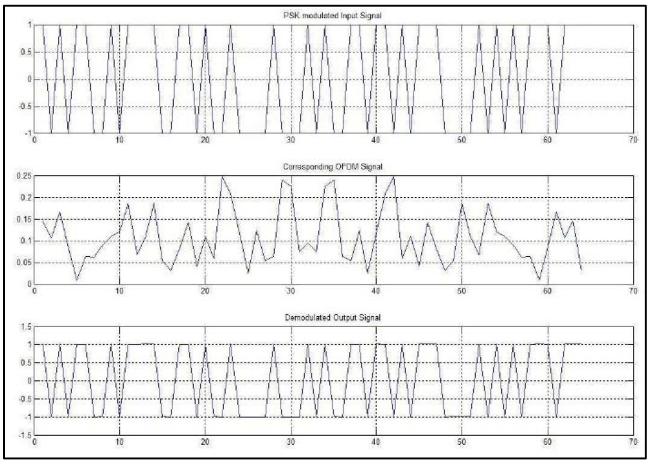
B. Bit error rate (BER) in OFDM using PSK as an Input Signal.



C. Effect of change in frequency offset in BER in OFDM.



D. A Simple OFDM Signal with PSK modulated input signal, and in absence of noise.



V. CONCLUSION

The OFDM makes efficient use of available spectrum by allowing overlapping among the carriers. It basically converts the high data rate stream in to several parallel lower data rate streams and thereby eliminating the frequency selective fading. It has been seen that the OFDM is a powerful modulation technique that is capable of high data rate and is able to eliminate ISI. It is computationally efficient due to the use of FFT techniques to implement modulation and demodulation functions. Using MATLAB software, the performance of OFDM system was tested for two digital modulation techniques namely BPSK and QPSK. From the simulation results, it is observed that the BPSK allows the BER to be improved in a noisy channel at the cost of maximum data transmission capacity. Use of QPSK allows higher transmission capacity, but at the cost of slight increase in the probability of error. This is because of the fact that QPSK uses two bits per symbol. Hence QPSK is easily affected by the noise. Therefore OFDM with QPSK requires larger transmit power. From the results, use of OFDM with QPSK is beneficial for short distance transmission link, whereas for long distance transmission link OFDM with BPSK will be preferable. Maximum likelihood estimation method was implemented for the calculation of timing and frequency offsets .These frequency offsets are found to disturb the orthogonality of the OFDM symbols. And it was observed that using this ML estimation method we can improve the performance of any OFDM system. There are several other techniques also to predict the timing an frequency offsets introduced by the system.

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