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Proposed OFDM System using Different Modulation Schemes and Varied Cyclic Prefix Length for WIMAX System

Sonika Thakur[1], Prof. Himanshu Monga[2]

[1-2]Dept. of Electronics and Communication Engineering, JNGEC Sundernagar

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Abstract—With the development of wireless communication, WiMAX has become the highly interested area for global telecom operators and manufacturers to meet the requirement of 4G.WiMAX uses orthogonal frequency division multiplexing (OFDM) technique for multiple transmissions. IEEE 802.16 (WiMAX) based OFDM system includes various modulation schemes as BPSK, QPSK and various levels of QAMs. Also Cyclic Prefix (CP) is the major part of the OFDM system. It is used to completely eliminate both Inter-Symbol Interference (ISI) and Inter-Carrier Interference (ICI) as long as the CP length is greater than the channel delay spread. The system performance can be checked by estimating the BER for various modulation schemes which are chosen on the basis of change conditions.

Keywords-WiMAX, OFDM, Cyclic Prefix, ICI, ISI, BER

1. INTRODUCTION

There is an ever increasing demand to increase the data throughput and to make more efficient use of the available spectrum in wireless data communication systems. The Orthogonal Frequency Division Multiplexing (OFDM) modulation technique is one of the methods used to achieve these goals efficiently. Due to its robustness against multi-path fading the OFDM is becoming a modulation technique of choice for most commercial high-speed broadband wireless communication systems. The OFDM is a special form of multi-carrier modulation schemes that is capable of overcoming the frequency selectivity of the radio channels and providing high data rates without the ISI[1][5]. However, in multipath fading channels, the time variation of a fading channel over an OFDM symbol period destroys the orthogonality between the sub-channel and leads to the ICI.

2. SYSTEM DESCRIPTION

Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier transmission technique specially derived to overcome the limitations of single carrier systems. The OFDM system divides the given spectrum into number of orthogonal carriers, which are closely spaced and each being modulated by a low rate data stream. With the removal of carrier spacing overhead, a highly effective spectrum utilization is achieved as compared to Frequency Division Multiple Access (FDMA)[2][3]. Orthogonality property of carriers will prevent interference between the closely spaced overlapping carriers. Due to orthogonal nature, there is no interference between the carriers because spectrum of each carrier has a null at the centre frequency of each of the other carriers in the system. As the delay spread must be very long to cause significant inter-symbol interference, the narrow bandwidth of each carrier gives rise to low symbol rate, and thus high tolerance to multi-path delay spread. Thus while considering the performance of the signal during the various stages it passes while transmission, inter-symbol interference[7] is an important factor. The block diagram of an OFDM system including cyclic prefix is as shown in figure1.

By using some modulation constellation like BPSK, QPSK, QAM etc, the wideband data stream of binary digits modulated and mapped to a symbol stream. By inverse multiplexing these symbols are de-multiplexed into N parallel streams. The constellation may be different, so some streams may carry a higher bit rate than others[4]. An inverse FFT is applied on each set of symbol which is giving set of complex time domain samples. These samples are then quadrature mixed to pass band in the standard way. The real and imaginary components are first converted to the analog domain using DAC's and then analog signals are used to modulate cosine and sine waves at the carrier frequency fc respectively. These signals are then summed to give the transmission signal s(t). The receiver picks up the signal r(t). The received signal is then quadrature mixed down to baseband using cosine and sine waves at the carrier frequency. This creates signals centered on 2fc. Therefore low-pass filters are used to reject these. The detailed block diagram of OFDM system is shown below in figure2.

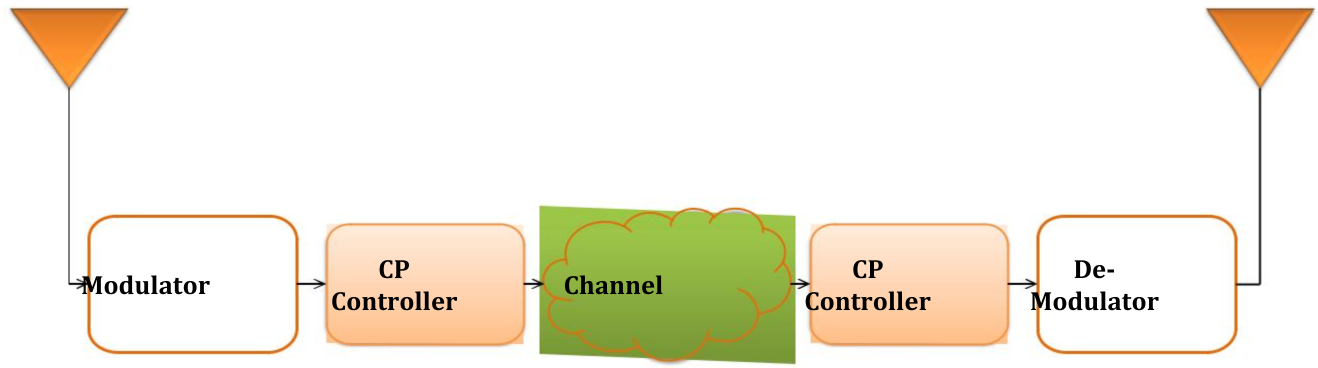

Fig. 1- Proposed block diagram of OFDM with cyclic prefix

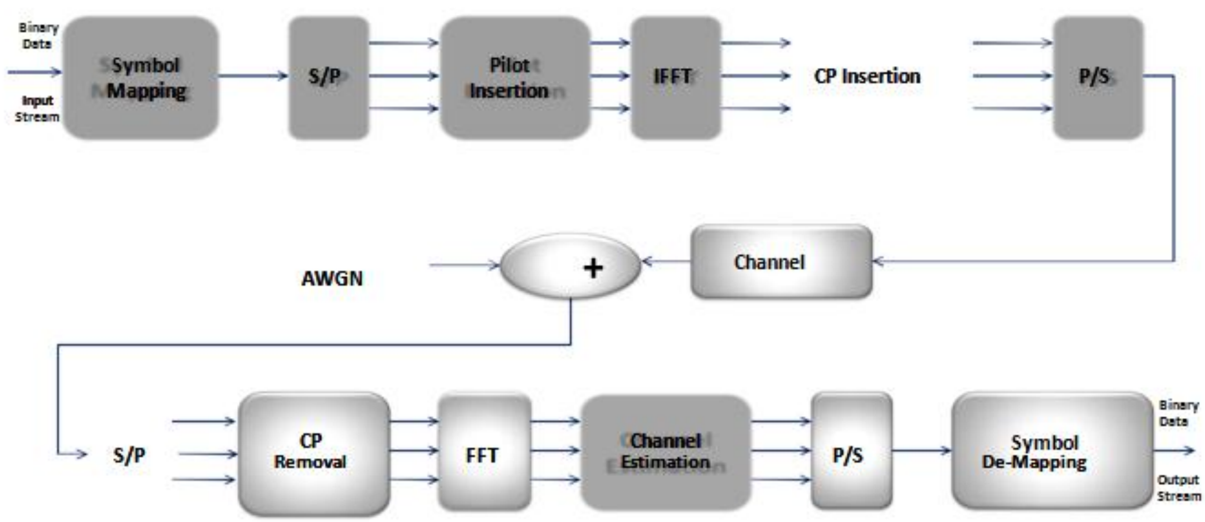

Fig.2- Block diagram of OFDM system

The baseband signals are then sampled and digitized using ADC's and a FFT is used to convert back to the frequency domain form time domain. This gives N parallel streams. Using an appropriate symbol detector each of which is converted to binary stream. Which is an estimate of the original binary stream at the transmitter by recombining these streams into a serial stream. While carrying out the above process of generation of OFDM, there were various design challenges. It was found that it was sensitive to frequency offset, hence needed frequency offset correction. It was also found to be sensitive to oscillator phase noise in the receiver end. Also it had a high peak to average power ratio. IFFT/FFT complexity was also involved. Other factors affecting the performance of an OFDM system were multi-path delay spread, channel noise, distortion (clipping), and timing requirements. Use of cyclic prefix and introduction of guard interval during that interval will improve performance of OFDM system and make it robust in worst case transmission scenarios as well. It is found that OFDM when compared with other multiple access schemes it performs extremely well and providing a very high tolerance to multi-path delay spread, peak power and clipping, and channel noise.

3. DIFFERENT MODULATION SCHEME

Modulation is the process of varying one or more properties of a carrier signal, which is a high frequency periodic waveform, with respect to a modulating signal. Modulation can be done by varying the amplitude, phase, or frequency of signal to be transmitted. But in case of an OFDM system, modulation[7] of frequency cannot be done because by doing so orthogonality of sub carriers carrying independent data would be lost.

Thus, an OFDM system can be modulated using BPSK, QPSK, QAM and the best modulation technique can be found on the analysis of bit error rate of the system under different modulation.

1. BPSK

BPSK is the simplest form of phase shift keying (PSK) and uses two phases which are separated by 180°, so can also be termed 2-PSK. Since it takes the highest level of distortion or noise to make the demodulator reach an incorrect decision so this modulation is the most robust of all the PSKs. It is, however, unsuitable for high data-rate applications when bandwidth is limited because it is only able to modulate at 1 bit/symbol.

2. QPSK

To minimize the BER, QPSK can encode two bits per symbol with four phases with Gray coding, twice the rate of BPSK. Analysis shows that this may be used either to double the data rate compared to a BPSK system while maintaining the data-rate of BPSK or to maintain the bandwidth of the signal the but
halve of bandwidth needed.

3. QAM

To distinguish between one signal vectors from another in presence of noise for a receiver depends on the distance between the vector end points. So if the signal vectors differ not only in phase, but also in amplitude, the noise immunity will improve. This type of system is known as amplitude and phase shift keying system. This system is called as quadrature amplitude phase shift keying (QASK), because in this system the direct modulation of carriers in quadrature is involved. Because of its multilevel nature and high bit rate, it is used in OFDM.

4. RESULT AND SIMULATION

OFDM system for four modulation techniques namely BPSK, QPSK, 16PSK and 64- PSK are shown in the figure 3. It is observed that to achieve a BER of 10-3 for optimum results, the OFDM system using BPSK modulation needs at least a SNR of 11dB, the OFDM system using a QPSK modulation needs at least 14dB, the OFDM system using 16- PSK modulation needs at least SNR around 25dB and the OFDM system using 64-PSK modulation needs at least SNR around 36dB

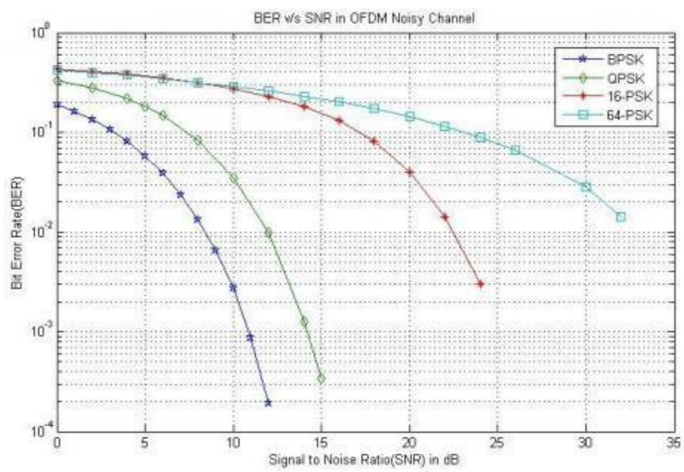

Fig: 3 Combative results of various modulation formats

5. CONCLUSION

From the obtained / simulated BER vs. SNR in a channel, it is concluded that OFDM is very lenient to the channel fading effects. SNR is somewhat greater in fading channel than an AWGN channel. Hence it can be concluded that OFDM is suitable for use in a fading channel too. We may use a particular modulation technique based on the type of data that is to be transmitted like BPSK, QPSK etc. In the generalized form, BPSK modulation format is recommended

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