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BER Analysis with OFDM using PSK/QAM Techniques for Wireless Communication

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Abstract: -

Orthogonal frequency division multiplexing (OFDM) now a day is becoming the chosen modulation technique for wireless communication networks. It is only because it can provide large data rates and is sufficiently robust in the face of radio channel impairments. Digital modulation techniques provide sufficient evolution of our mobile wireless communications by increasing the capacity, speed and quality of a wireless networks. In this paper, We concentrate on digital modulation schemes, such as PSK (Phase Shift keying) and QAM (Quadrature Amplitude Modulation) over an additive white Gaussian Noise (AWGN) channel to analyze the performance of an OFDM system in terms of bit error rate (BER). This is evaluated through a computer simulation, the results from which make it clear that, for high-capacity data rate transmission, the QAM modulation is better than the PSK modulation.

Keywords: PSK, QAM, OFDM, BER, AWGN

I. INTRODUCTION

The growth in the uses of wireless networks has led to the need for new communication techniques with higher data rates. OFDM is a powerful modulation technique used to achieve a high data rate and is able to eliminate inter-symbol interference (ISI). It is computationally efficient due to the use of fast Fourier transform (FFT) techniques for implementing modulation and demodulation methodology [1]. Mainly OFDM scheme have a large number of orthogonal, overlapping, narrow-band sub-carriers, which got transmitted in parallel, divides the total transmission bandwidth. OFDM modulation technique used is being imposed in many new broadband communication schemes, including digital tele-transmission, digital broadcasting, ADSL and wireless LANs. It also allows digital data to be efficiently and reliably transmitted over a radio channel, even in multipath environments [2]. In OFDM, even sub-carriers overlaps but this does not causes any problem since these are orthogonal, that is, at a time the peak of one occurs when that of others subcarrier becomes zero. This is achieved by realizing all the subcarriers together using the inverse fast Fourier transform (I-FFT). The analysis of BER performances have suggested that OFDM is better than CDMA which is currently incorporated in most existing 3G systems [3-4]. A major problem in most wireless systems is the presence of a multipath channel & multipath fading. In this environment, the transmitted signal reflects off several objectives and a result, multiple delayed parts of the transmitted signal arrive at the receiver which causes the received signal to be distorted. Many wired systems also have a similar problem with reflection occurring due to impedance mismatches in the transmission line. A multipath channel will cause two problems for an OFDM system. The first is ISI which occurs when the received OFDM symbol is distorted by the previously transmitted OFDM symbol and has a similar effect to the ISI that occurs in a single-carrier system. However, in such systems, the interference is typically due to several symbols other than only the previous ones; and the symbol period is typically much shorter than the time span of the channel, whereas the typical OFDM symbol period is much longer than the time span of the channel. The second problem is unique to multi-carrier systems and is called intra-symbol interference which is the result of interference amongst a given OFDM symbol’s own sub-carriers. An adaptive modulation and coding technique for overcoming any ISI and analyzing the performance of the BER is proposed in previous work mentioned in [5].

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

A. OFDM TRANSCEIVER

In this section, we mainly emphasize the OFDM transceiver system, before transmitting information bit over an AWGN channel through the OFDM transmitter; we use the PSK and QAM modulation schemes shown in Fig.1. The transmitter section converts the digital data to be transmitted, into a mapping of the sub-carrier's amplitude and phase using modulation techniques. The spectral representation of the data is then transformed into the time domain using an IFFT which is much more computationally efficient and used in all practical systems [7, 8]. The addition of a cyclic prefix to each symbol solves both ISI and inter-carrier interference (ICI) [9, 10]. The digital data is then transmitted over the channel. After the time-domain signal passes through the channel, it is broken down into the parallel symbols and the prefix is simply discarded. The receiver performs the reverse operation to that of the transmitter.

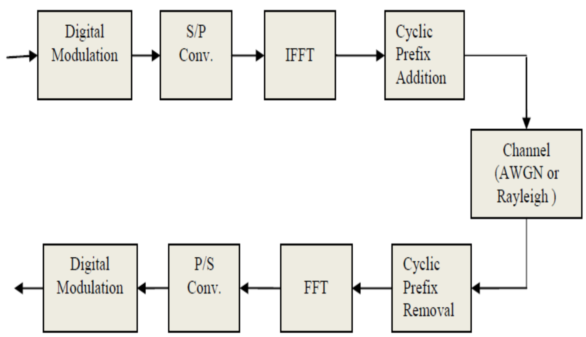

Fig1. OFDM Transceiver Block Diagram

The amplitude and phase of the sub-carrier are then selected and converted back to digital data. In OFDM, multiple sinusoidal with frequency separation 1/T are used, where T is the active symbol period. The information g_k to be sent on each sub-carrier k is multiplied by its corresponding carrier $g_k(t) = e^{\frac{j2\pi kt}{T}}$ And the sum of such modulated sinusoidal forms the transmit signal. Therefore, the sinusoidal used in OFDM can be defined as [11]:

$$\mathbf{g_k(t) = \frac{1}{\sqrt{2}} e^{\frac{j2\pi kt}{T}} w(t)}$$

Where, k= 0, 1, N-1 corresponds to th3e sinusoidal and w (t) =u (t)-u (t-T) is a regular window over [0, T].

Science the OFDM system uses multiple sinusoidal signals with frequency separation of 1/T, each sinusoidal is modulated by independent information. Mathematically we can write a transmit signal over the channel as,

$$\mathbf{s(t) = \delta_0\, g_0(t) + \delta_1\, g_1(t) + \ldots + \delta_{N-1}\, g_{N-1}(t)}$$

$$\mathbf{= \sum_0^{N-1} \delta_k g_k(t)}$$

$$\mathbf{= \sum_0^{N-1} \delta_k\, e^{\frac{j2\pi kt}{T}} w(t)}$$

Where, δ_k is the k^{th} symbol in the message symbol in the message symbol sequence for k in [0, N-1], where N is the number of carriers.

In an OFDM receiver, we multiply the received signal by a bank of correlators and integrate it over period T.

Therefore, the information sent on subscriber k is

$$\mathbf{\frac{1}{T}\int_T s(t)\, e^{-\frac{j2\pi mt}{T}} = \begin{cases} g_k , m = k \\ 0 , m \neq k \end{cases}}$$

Where, m takes its values from 0 to k-1.

As we consider the AWGN channel, we can remove the frequency domain equalizer block from the above OFDM transceiver system because a frequency domain equalizer is helpful only if the channel introduces multipath fading.

B. USE INVERSE FOURIER TRANSFORM

OFDM uses the available spectrum efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to one another, preventing interference between the closely spaced carriers. To generate OFDM successfully the relationship between all carriers must be carefully to maintain the orthogonality of the carriers. For that, after choosing the spectrum required, we have to convert it back to its time domain signal using an Inverse Fourier Transform.

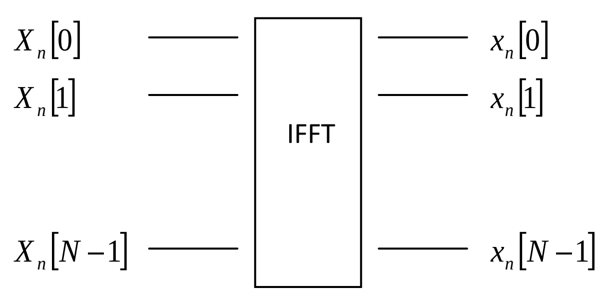

Fig2. Sequence Transformation using Inverse Fourier Transformation

C. ADVANTAGES OF OFDM

Makes efficient use of the spectrum by allowing overlap, by dividing the channel into narrowband flat fading sub-channels, OFDM is more resistant to frequency selective fading than single carrier systems are. Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel. Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems. It is possible to use maximum likelihood decoding with reasonable complexity, as discussed in OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions.

D. DISADVANTAGES OF OFDM

The OFDM signal has a noise like amplitude with a very large dynamic range; therefore it requires RF power amplifiers with a high peak to average power ratio. Secondary, It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT.

III. RESULTS

In this paper, we have evaluated the BER performance of an OFDM system with two digital modulation schemes, namely M-ary PSK and M-ary QAM, over an AWGN channel. OFDM is a powerful modulation technique to achieve high data rate and is able to eliminate ISI. It is computationally efficient due to its use of FFT techniques for implementing modulation and demodulation functions.
As we have done the analysis for PSK & QAM modulation techniques.

Analysis using M-PSK Modulation Technique

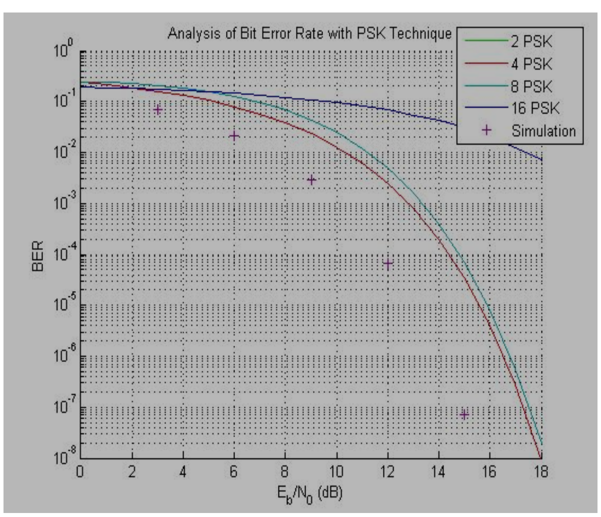

Fig3. Bit error rate with 2-PSK, 4-PSK,8-PSK,16-PSK & Monte Carlo Simulation.

Analysis using M-QAM Modulation Technique

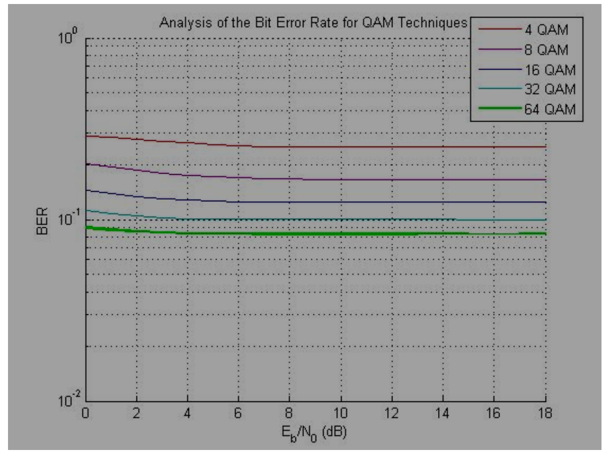

Fig4. Bit error rate with 2-PSK, 4-PSK,8-PSK,16-PSK & Monte Carlo Simulation.

IV. CONCLUSION

It is observed from the M-ary PSK BER plots that the BER is less in the case of 4-PSK for a low Eb/N0 than in the 8- PSK and 16-PSK cases. It shows as a higher value of M-ary PSK increases spectrum efficiency, but is easily affected by noise, the OFDM system with the higher M-PSK scheme is used for large-capacity, long-distance application at the cost of slight increase in Eb/N0 while that with the QPSK scheme is suitable for low-capacity, short-distance application. The comparison of M-ary PSK and M-ary QAM schemes indicate that, the BER is large in M-PSK as compared to M-QAM and it is generally depending on its applications. For a higher value of M, such as M > 16, the QAM modulation scheme is suitable for OFDM. In both cases, I obtain good performances but of these two modulation schemes I conclude that for a high capacity data rate transmission M-ary QAM modulation is better than the M-ary PSK modulation.

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