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Performance Evaluation of OFDM System under Various Modulation Techniques and Various Channels.

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Abstract

Now, a day the need for high speed data transmission is increased. The OFDM is method of encoding digital data on multiple carrier frequencies. In OFDM the various modulation techniques are used. The primary function of OFDM is its orthogonally because it has multiple sub–carriers. The orthogonally allows high spectral efficiency [5]. High data rate and secure data communication has become an unavoidable need of every mobile users. The highest bit rates in commercially deployed wireless system are achieved by means of orthogonal frequency division multiplexing (OFDM). The next advance in cellular systems, under investigation by 3rd generation partnership project (3GPP), also anticipates the adoption of OFDMA to achieve high data rates. In multipath fading the channel impulse response fluctuates for different subcarrier in different time slots [2]. But with various channels and modulation techniques OFDM system can use coherent detection instead of differential.

1. Introduction

OFDM is a method of digital modulation in which a signal is split into several narrow band channels at different frequencies. OFDM is similar to conventional frequency division multiplexing (FDM).The difference lies in the way in which the signals are modulated and demodulated [1]. It is being considered as a method of obtaining high speed digital data transmission over conventional telephone lines and also used in wireless local area network. OFDM uses the spectrum much more 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 [3]. OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation schemes used. Each carrier to be produced is assigned some data to transmit. The required amplitude and phase of the carrier is then calculated based on modulation schemes like, BPSK, QPSK or QAM. The require spectrum is then converted back to its time domain signal using an inverse Fourier transform. OFDM reduces the amount of crosstalk in signal transmission. 802.11a WLAN, 802.16 and WIMAX technologies use OFDM.

2. OFDM System and Channel Model

Firstly at the transmitter side, the binary information is first grouped and mapped into complex valued symbols according to the modulation by different mapping schemes such as BPSK, QPSK, 16QAM and 64QAM. After this the data will send to serial to parallel converter to prepare different data groups for different OFDM sub-carriers. The mapped signals are modulated into N orthogonal sub-carriers by the IFFT. A cyclic prefix is then added to De multiplexed IFFT output. So finally, the obtained signal is converted to a time continuous analogy signal before it is transmitted through the channel. Now at the receiver side an opposite operation is carried out and the information data is detected. The channel estimation can be performed by either inserting pilot tones into all of the subcarriers of OFDM symbols with a specific period or inserting pilot tones into each OFDM symbol. Each carrier in an OFDM system is a sinusoid with a frequency that is an integer multiple of a base or fundamental sinusoid frequency [4]. OFDM signal is created in the frequency domain, and then transformed into the time domain via the Discrete Fourier Transform (DFT).

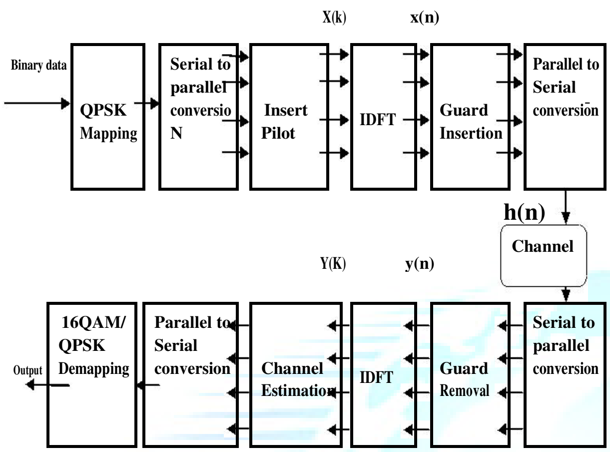


Figure.1

The binary information is first grouped and mapped according to the modulation in "signal mapper". After inserting pilots either to all sub-carriers with a specific period or uniformly between the information data sequence, IDFT block is used to transform the data sequence of length N {X(k)} into time domain signal {x(n)} with the following equation

$$x(n) = IDFT\{x(k)\} = \sum_{k=0}^{N-1} X(k)\, e^{\frac{j2\pi kn}{N}} \quad (1)$$

where N is the DFT length. Following IDFT block, guard time, which is chosen to be larger than the expected delay spread, is inserted to prevent inter-symbol interference [1]. This guard time includes the cyclically extended part of OFDM symbol in order to eliminate inter-carrier interference (ICI). The resultant OFDM symbol is given as follow

$$x_f(n) = \begin{cases} x(N+n), & n = -N_g, \ldots, -N_g+1 \\ x(n), & n = 0, 1, \ldots, N-1 \end{cases} \quad (2)$$

where N_g is the length of the guard interval. After following D/A converter, this signal will be sent from the transmitter with the assumption of the baseband system model. The transmitted signal will pass through the frequency selective time varying fading channel with additive noise. The received signal is given by:

$$y_f = x_f(n) * H(n) + w(n) \quad (3)$$

Where w(n) is additive white Gaussian noise and h(n) is the channel impulse response ,which is equal to

$$H(n) = \sum_{i=0}^{r-1} h_i\, e^{\frac{j2\pi f_{D_i} Tn}{N}}\, \delta(\lambda - \tau_i), \quad 0 < n < N-1 \quad (4)$$

where r is the total number of propagation paths, h_i is the complex impulse response of the i^{th} path, f_{Di} is the i^{th} path Doppler frequency shift, λ is delay spread index, T is the sample period and τ_i is the i^{th} path delay normalized by the sampling time.

At the receiver, after passing to discrete domain through A/D and low pass filter, guard time is removed:

$$y(n) = y_f(n + N_g), \quad n = 1, 2, \ldots, N-1 \quad (5)$$

Then y(n) is sent to DFT block for the following operation.

Assuming there is no ISI, then

$$Y(k) + H(k) = DFT\{h(n)\} \quad (6)$$

I(k) that is ICI because of Doppler frequency and W(k)=DFT{w(n)}, with the following equation:

$$Y(k) = X(k)H(k) + I(k) + w(k) \quad (7)$$

3. Wireless Channel Modelling

Wireless communication has become a very important and prominent part of everyday life. Working of channel accurately is very important part for the design of wireless communication. During the transmission fading or loss of signal may take place .Fading helps in learning various things like fading patter in different environment and condition [5]. The better a model can describe a fading the better it can compensate with other signals. Due to this our signal is error free or we can ensure that error might be less .This ensure the accuracy level over wireless medium. Selection of fading model is an important issue in the development of wireless application. QPSK, BPSK, DPSK and QAM helps in application development in real-world.

4. Multipath and Fading

Generally Fading means distortion of signal. To know the about fading the concept of multipath should be clear. Multipath in wireless communication means radio signal reaching at antenna by two or more paths

.Various factors which leads to the two or more path of signals are, distortion, phase shift, of signal. Distortion caused due to multipath of the signal is known as fading[3].The phenomenon of diffraction and scattering give rise to additional radio propagation paths beyond the path between receiver and transmitter.

During the transmission process communication channel has to face different fading phenomenon. Due to these fading channel multipath is generated. Multipath leads, some signals aid the direct path and other paths subtract it.

5. Causes of Fading

Doppler shift, reflection, diffraction, scattering. First factor is Doppler shift. Due to the relative motion between the mobile and the base station, each multipath wave experiences an apparent shift in frequency. The shift in received signal frequency due to motion is called Doppler shift. It is directly proportional to the velocity and direction of motion of the mobile with respect to the direction of arrival of the received multipath wave. Doppler shift will be positive or negative depending on whether the mobile receiver is moving towards or away from the base station. Diffraction is due to the bending of wave around the obstacle. Diffraction looks like a reflection at high frequencies [3]. It Depend upon the amplitude, phase and polarisation. Scattering due to the rough surfaces and irregularities in the channel scattering takes place or scattered waves takes place. Electric poles induce scattering in the communication.

6. Types of Fading

In wireless communication there is large scale fading and small scale fading. The small scale fading based on delay spread is flat fading and frequency selective fading and based on Doppler spread is fast fading and slow fading.

6.1. Flat fading

A received signal is said to have underwent Flat Fading if “The Mobile Radio Channel has a constant gain and linear phase response over a Bandwidth which is greater than the Bandwidth of the transmitted Signal Fading in which all frequency components of a received radio signal vary in the same proportion simultaneously.

6.2. Frequency selective fading

The channel creates frequency selective fading on the received signal when the channel possesses a constant gain and linear phase response over a bandwidth, which is smaller than the bandwidth of the transmitted signal. Under these conditions the channel impulse response has a multipath delay spread which is greater than the reciprocal bandwidth of the transmitted message waveform so the received signal includes multiple versions of the transmitted waveform, which are attenuated and delayed in time, and hence the received signal is distorted.

6.3 Slow fading

Here in Slow Fading channel the channel impulse response changes at a rate much slower than the transmitted baseband signal the channel may be assumed static over one or several bandwidth intervals. In the frequency domain, this implies that the Doppler spread of the channel is much less than the bandwidth of the baseband signal

$$T_s > T_c \; \& \; B_s < B_d$$

6.4 Fast fading

In Fast Fading channel the channel impulse response changes at a rate much faster than the transmitted baseband signal. In other words the coherence time of the channel is smaller than the symbol period of the transmitted signal. This causes frequency dispersion due to Doppler spreading, which leads to signal distortion. When viewed in frequency domain, signal distortion due to fast fading increases with increasing

Doppler spread relative to the bandwidth of the transmitted signal.

$$T_s > T_c \text{ and } B_s < B_d$$

8. Modulation

Modulation is the process whereby some characteristic of one wave is varied in accordance with some characteristic of another wave. The basic types of modulation are angular modulation (including the special cases of phase and frequency modulation) and amplitude modulation. In missile radars, it is common practice to amplitude modulate the transmitted RF carrier wave of tracking and guidance transmitters by using a pulsed wave for modulating, and to frequency modulates the transmitted RF carrier wave of illuminator transmitters by using a sine wave.

8.1. Digital Modulation

In digital modulation, an analog carrier signal is modulated by a discrete signal. Digital modulation methods can be considered as digital-to-analog conversion, and the corresponding demodulation or detection as analog-to-digital conversion. The changes in the carrier signal are chosen from a finite number of M alternative symbols [2]. The most fundamental digital modulation techniques are based on keying are PSK (phase-shift keying) a finite number of phases are used, FSK (frequency-shift keying) a finite number of frequencies are used, ASK (amplitude-shift keying) a finite number of amplitudes are used and QAM (quadrature amplitude modulation) a finite number of at least two phases and at least two amplitudes are used. Quadrature amplitude modulation (QAM) - It is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by modulating the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature component. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK).

9. Bit Error Rate

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. The bit error rate (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage

.The bit error probability p_e is the expectation value of the BER. The BER can be considered as an approximate estimate of the bit error probability. This estimate is accurate for a long time interval and a high number of bit errors.

10. Signal to Noise Ratio (SNR)

Signal-to-noise ratio, or SNR, is a measurement that describes how much noise is in the output of a device, in relation to the signal level. Every device has some amount of noise at its output. A small amount of noise may not objectionable if the output signal is very strong. SNR is actually two level measurements, followed by a simple calculation. First, we measure the output level of the device under test with no input signal [3]. Then we apply a signal to the device and take another level measurement.

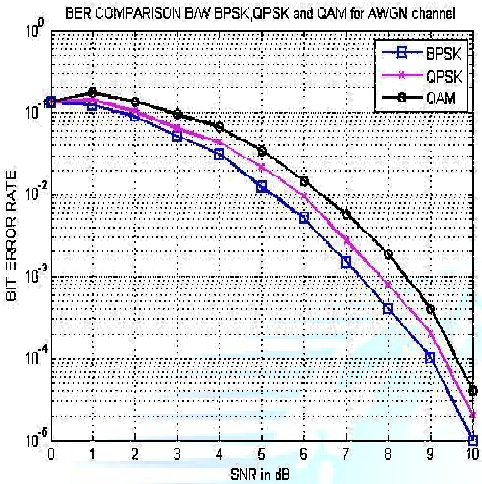
$$SNR = P_{Signal} / P_{Noise} .$$

Signal-to-noise ratio is defined as the power ratio between a signals information and the background noise.

11. Simulation Results

In my simulation I have used a MATLAB 7.0 for simulation for the Bit Error Rate (BER) Performance of OFDM system. In figure(2) I have compared the performance of BPSK, QPSK and QAM with AWGN channel. After simulation I has been found that the bit error rate is minimum in case of BPSK and bit error rate of QPSK is minimum as compared to the QAM.

Figure2.



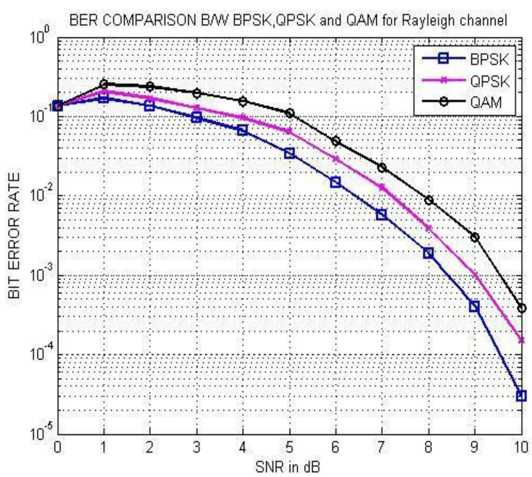
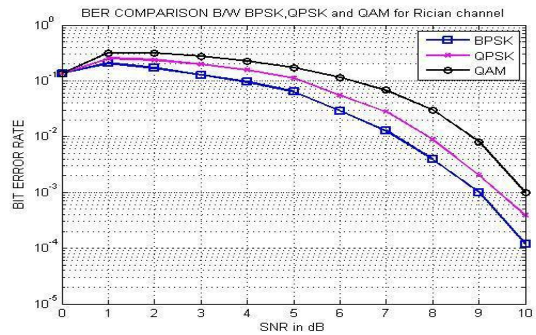


Figure3.

Figure (3) compare bit error rate between different modulation techniques like BPSK, QPSK and QAM for Rayleigh channel. So it is find from figure (3) that BPSK modulation has less bit error rate as compared to the QPSK and QAM modulation.

Figure (4) compare the bit error rate between BPSK, QPSK and QAM modulation techniques for Rician channel. From the simulation result it has been found that the bit error rate for BPSK is less than the QPSK and QAM modulation. Orthogonal Frequency division multiplexing techniques improves the channel impairments conditions. OFDM bit error rate can be improved by pilot channel channels estimation. Pilot symbols works as a reference signals.

Figure4.



12. Conclusion

In wideband mobile channel, OFDM has been proven a feasible method for improving channel conditions. From figure 2, figure 3 and figure 4 it has been notified that bit error rate performance of OFDM system for AWGN channel is better than the Rayleigh and rician channel. BPSK modulation has less error as compared to the QPSK and QAM for AWGN channel, Rayleigh channel and Rician channel.

References

[1] Yong Soo Cho, Won young Yang, "MIMO-OFDM Wireless communication With Matlab".

[2] Y.Li,"Pilot-Symbol-Aided Channel Estimation for

OFDM in Wireless Systems", in *IEEE Transactions on Vehicular Technology*, vol. 49, no.4, July 2000.

[3] Uma Shanker Jha, "OFDM Towards fixed and Mobile broadband wireless Access".

[4] T.S.Rappaport, "Wireless Communication",

Prentice Hall, 2009.

[5] M. Hsieh and C. Wei, "Channel estimation for

OFDM systems based on comb-type pilot arrangement in frequency selective fading channels" in *IEEE Transactions on Consumer Electronics,* vol. 44, no.1, February 2002