Evaluating the performance of different modulation techniques in OFDM

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Abstract

OFDM is turning into the chosen modulation technique for wireless communication to reduce multipath fading effects and to provide massive data rates. OFDM is a multicarrier transmission system that utilizes the method of ripping smaller subcarriers of frequencies to agitate multipath drawback. Multipath distortion and Frequency interference are decreased through this system. OFDM has been accustomed develop the capability of CDMA networks and fulfils the wireless access technique for 4G networks. OFDM is meant to attain during a superior method just in that matter of frequency selective fading and narrowband interference. OFDM cuts the extent of interference in signal broadcasting .In this paper, we evaluated the performance of OFDM at different modulation techniques through BPSK,QPSK,16 QAM and 64 QAM and plot the graph between SNR and BER.The 64 QAM has the highest bit error rate and 64 QAM has the lowest bit error rate.

Keywords: *BPSK; QPSK;16 QAM;64 QAM; SNR and BER.*

I. Introduction

Orthogonal frequency division multiplexing (OFDM) is a parallel transmission scheme, where a high-rate serial data stream is split up into a set of low-rate sub streams, each of which is modulated on a separate sub-carrier (SC) (frequency division multiplexing). Thereby, the bandwidth of the sub-carriers becomes small compared with the coherence bandwidth of the channel, i.e., the individual sub-carriers experience flat fading, which allows for simple equalization. This implies that the symbol period of the sub-streams is made long compared to the delay spread of the time-dispersive radio channel. Selecting a special set of (orthogonal) carrier frequencies, high spectral efficiency is obtained, because the spectra of the sub-carriers overlap, while mutual influence among the sub-carriers can be avoided. The derivation of the system model shows that, by introducing a cyclic prefix (the so-called guard interval (GI)), the orthogonality can be maintained over a dispersive channel. Multi band OFDM Ultra-Wide Band transmits data simultaneously over multiple carriers spaced apart at precise frequencies on more than one band. OFDM signal needs precisely overlapping but non-interfering carriers, and achieving this precision requires the use of a real-time Fourier transform, which became feasible with improvements in Very Large-Scale Integration (VLSI). Basically, multi band OFDM system provides time-domain diversity by time-domain symbol spreading technique and frequency-domain diversity by transmitting OFDM symbols in different sub-bands. Fast Fourier Transform algorithms provide nearly 100 percent efficiency in capturing energy in a multi-path environment, while only slightly increasing transmitter complexity.

Beneficial attributes of multi band OFDM include high spectral flexibility and resiliency to RF interference and multi-path effects. Although a wide band of frequencies could be used from a theoretical viewpoint, certain practical considerations limit the frequencies that are normally used for multi band OFDM ultra-wide band communication. Limiting the upper bound simplifies the design of the radio and analogue front-end circuitry as well as reducing interference with other services. An OFDM system offers inherent robustness to multi-path dispersion with a low-complexity receiver. Adding a Cyclic Prefix (CP) forces the linear convolution with the channel impulse response to resemble a circular convolution. A circular convolution in the time domain is equivalent to a multiplication operation in the frequency domain. An important stage in the implementation of OFDM is the modulation of the baseband signal along with the various subcarriers. Baseband signal cannot be transmitted without modulation. Information of baseband signal is transmitted in the way that parameter of high frequency carrier wave, such as amplitude or phase, is modulated by baseband signal, hence conveys the information that can be restored to original signal at the receiver. Selection of proper modulation scheme is essential to communication system design. In this research paper, we present the analysis of various modulation schemes in respect to their performance in terms of BER. For this research work, we have taken BPSK, QPSK, 16 QAM, 64 QAM as the modulation schemes and have compared the performance in terms of BER and power spectral density, in a Rayleigh Fading Channel.

II. System model

OFDM is a form of multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers. When modulation of any form - voice, data, etc. is applied to a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result, when signals are transmitted close to one another they must be spaced so that the receiver can separate them using a filter and there must be a guard band between them. This is not the case with OFDM. Although the sidebands from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each another. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.

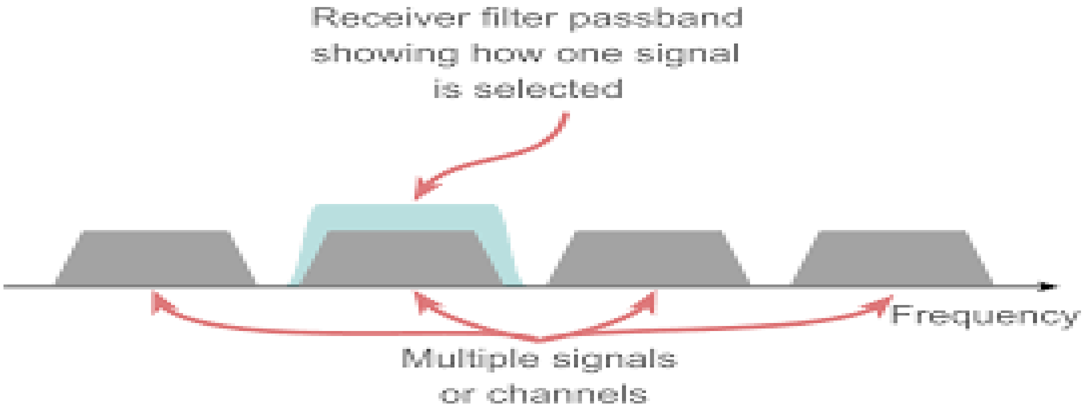

Figure 1: Traditional-selection if signals on different channels

To see how OFDM works, it is necessary to look at the receiver. This acts as a bank of demodulators, translating each carrier down to DC. The resulting signal is integrated over the symbol period to regenerate the data from that carrier. The same demodulator also demodulates the other carriers. As the carrier spacing equal to the reciprocal of the symbol period means that they will have a whole number of cycles in the symbol period and their contribution will sum to zero - in other words there is no interference contribution. If N subcarriers are used, and each subcarrier is modulated using M alternative symbols, the OFDM symbol alphabet consists of M^N combined symbols. The low-pass equivalent OFDM signal is expressed as:

$$\nu(t) = \sum_{k=0}^{N-1} X_k e^{j2\pi kt/T}, \quad 0 \le t < T, \qquad (1)$$

Where, N is the number of subcarriers, and T is the OFDM symbol time. The subcarrier spacing of makes them orthogonal over each symbol period; this property is expressed as:

$$\frac{1}{T}\int_0^T \left(e^{j2\pi k_1 t/T}\right)^* \left(e^{j2\pi k_2 t/T}\right) dt = \frac{1}{T}\int_0^T e^{j2\pi(k_2-k_1)t/T} dt = \delta_{k_1 k_2} \qquad (2)$$

To avoid inter-symbol interference in multipath fading channels, a guard interval of length T is inserted prior to the OFDM block. During this interval, a cyclic prefix is transmitted such that the signal in the interval -Tg < t < 0 equals the signal in the interval (T-Tg) < t < T. The OFDM signal with cyclic prefix is thus:

$$\nu(t) = \sum_{k=0}^{N-1} X_k e^{j2\pi kt/T}, \quad -T_g \le t < T \qquad (3)$$

The low-pass signal above can be either real or complex-valued. Real-valued low-pass equivalent signals are typically transmitted at baseband wireline applications such as DSL use this approach. For wireless applications, the low-pass signal is typically complex-valued; in which case, the transmitted signal is up-converted to a carrier frequency fc. In general, the transmitted signal can be represented as:

$$s(t) = \Re\left\{\nu(t) e^{j2\pi f_c t}\right\} = \sum_{k=0}^{N-1} |X_k| \cos\left(2\pi[f_c + k/T]t + \arg[X_k]\right) \qquad (4)$$

III. Different Modulation schemes

a) BPSK (Binary Phase Shift Keying)

The most straightforward type of PSK is called binary phase shift keying (BPSK), where "binary" refers to the use of two phases offsets (one for logic high, one for logic low).We can intuitively recognize that the system will be more robust if there is greater separation between these two phases of course it would be difficult for a receiver to distinguish between a symbol with a phase offset of 90° and a symbol with a phase offset of 91°. We only have 360° of phase to work with, so the maximum difference between the logic-high and logic-low phases is 180°. But we know that shifting a sinusoid by 180° is the same as inverting it; thus, we can think of BPSK as simply inverting the carrier in response to one logic state and leaving it alone in response to the other logic state.

b) QPSK (Quadrature Phase Shift Keying)

Quadrature phase-shift keying is now the mainstream method used for modulation in cable modems, satellites, and numerous other wireless communication schemes. The signature constellation pattern of QPSK and related digital modulations schemes can be a bit baffling to novices. Here's a simple primer on the fundamentals of the method, why the constellation pattern arises, and how to display it. If a digital signal is used as the input to a conventional frequency modulator, the output will consist of a sine wave containing two distinct frequencies. Getting the original digital signal back requires a demodulation process that consists of passing the modulated signal through two filters, then translating the resulting signal back into logic levels.

c) QAM (Quadrature Amplitude Modulation)

Quadrature amplitude modulation (QAM) is a modulation scheme used for both digital and analog signals. QAM doubles the effective bandwidth by combining two amplitude-modulated signals into a single channel.

(i) 16-QAM

- 16-QAM: 16-state quadrature amplitude modulation. Four I value and four Q values are used, yielding four bits per symbol. 16 states because 24 = 16.
- Theoretical bandwidth efficiency is four bits/second/Hz.Data is split into two channels, I and Q
- As with QPSK, each channel can take on two phases. However, 16-QAM also accommodates two intermediate amplitude values!
- Two bits are routed to each channel simultaneously • The two bits to each channel are added, then applied to the respective channel's modulator.

(ii) 64-QAM

- A variation on the quadrature amplitude modulation (QAM) signal modulation scheme.
- 64-QAM yields 64 possible signal combinations, with each symbol representing six bits (2 6 = 64).
- The yield of this complex modulation scheme is that the transmission rate is six times the signaling rate.

IV. Results and Discussion

Figure 5 shows the BER vs SNR plot for different modulation techniques using BPSK,QPSK,16 and 64 QAM.So,from the figure it can be seen that BPSK has a BER of 0.2 at SNR 9 dB, QPSK has a BER of 0.5 at SNR 13 dB, 16 QAM has a BER of 0.08 at SNR 20 dB and 16 QAM has a BER of 0.9 at SNR 22 dB . It can be seen that with increasing modulation techniques complexity increases and hence BER increases.

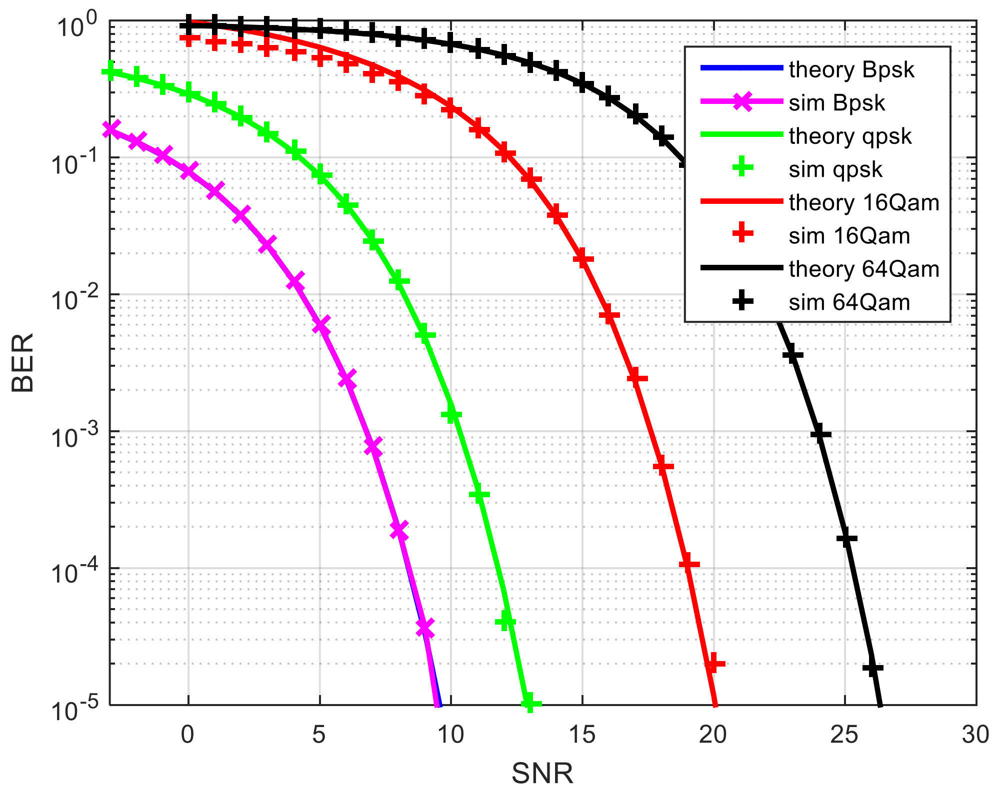

Figure 2 : SNR vs BER for different modulation techniques in OFDM

V. Conclusion

In this paper, Monte Carlo simulation were used in the downlink to demonstrate the performance of the OFDM in downlink with different modulation was used at basic modulation techniques to evaluate the performance of the OFDM. Simulations were performed for BPSK, QPSK,16 and 64 QAM.BER and SNR tools were used to evaluate the graphical performance. It was observed that with increase in modulation technique complexity increases. Moreover, with the implementation of this technique, it can be used for next generation wireless communication.

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