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FEASIBILITY ANALYSIS OF OFDM SYSTEM BASED ON PHASE NOISE, PIXEL ERROR AND BIT ERROR RATE IN REAL ENVIRONMENT

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ABSTRACT

This paper aims at contributing to find out the feasibility of Orthogonal Frequency Division Multiplexing (OFDM)system usingPhase Shift Keying (PSK) modulation. A simulation model of OFDM system has been developed to analyze the phase noise by using a user's choice image. Based on the model a performance comparison is carried out between the phase noise and SNR for different number of constellation points using PSK modulation. Simulation result shows that BPSK modulation reduces the phase noise of OFDM system more efficiently with the increase of SNR. Moreover it produces the best result for reducing phase noise when the number of subcarrier increases. Furthermore constellation diagram of phase noise and varying input Signal to Noise Ratio (SNR) values is also analyzed to prove the efficiency of the BPSK modulation in OFDM system.Finally BER, pixel error rate and image quality for different values of SNR by using employed image is calculated and compared.From this performance analysis it can be concluded that BPSK has lower BER, pixel error rate and higher image quality in OFDM system.

Keywords*:* BER, OFDM,phase noise, pixel error, PSK, SNR

INTRODUCTION

The demand for high speed mobile wireless communication is rapidly growing. OFDM technology promises to be a key technique for achieving the high data capacity and better spectral efficiency requirements of wireless communication systems in the near future. It is a special case of multi-carrier modulation.It is based upon the principle of frequency division multiplexing (FDM) technique where each frequency channel is modulated with simpler modulation scheme. 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 single carrier. Recently, OFDM systems are being applied for fixed and mobile transmission. Some examples of existing systems where OFDM is used are digital audio and video broadcasting and Asymmetric Digital Subscriber Line (ADSL) modems. Moreover, the new generation of Wireless Local Area Networks systems (WLANs) is based on similar WLAN standards known as IEEE 802.11a (US) and Hiperlan/2 (Europe). These systems support a physical layer transmission rate up to 54 Mbps and use OFDM for the physical layer implementation. Additionally, OFDM is being considered for future broadband applications such as Wireless Asynchronous Transfer Mode (ATM) and fourth generation transmission techniques. There are many advantages of OFDM system such as multipath delay spread tolerance, immunity to frequency selective fading channel, high spectral efficiency, efficient modulation and demodulation, robustness to impulse response and so on (Tomba 1998; Armada and Calvo 1998; Armada 2001). Though it has many advantages some drawbacks are still unresolved. One of the major problems of OFDM system is phase noise caused by oscillator instabilities and frequency fluctuations in both the transmitter and the receiver.A number of approaches have been proposed to deal with the phase noise problem (Lee*et.al*. 2005; Syrjälä*et.al*. 2009;Zou*et.al*. 2007; Syrjala and Valkama 2010; Ma 2013). However, these are not easily related to the oscillator specifications needed by the system designers. The purpose of this paper is to analyze the OFDM system using PSK modulation. To analyze the OFDM system at first a simulation model is developed which is based on PSK modulation. Then a user's choice image is used as a source and analyzes the phase noise to find out which PSK modulation reduces the phase noise more efficiently. To prove the efficacy of the employed best modulation technique BER, pixel error rate and image quality for different values of SNR is also analyzed and compared in this paper.

SYSTEM MODEL

Orthogonal frequency division multiplexing is a multicarrier modulation technique that divides the available spectrum into subcarrier. It is a parallel transmission scheme. Each carriers is orthogonal to each other. The system model which is used in this research is shown below:

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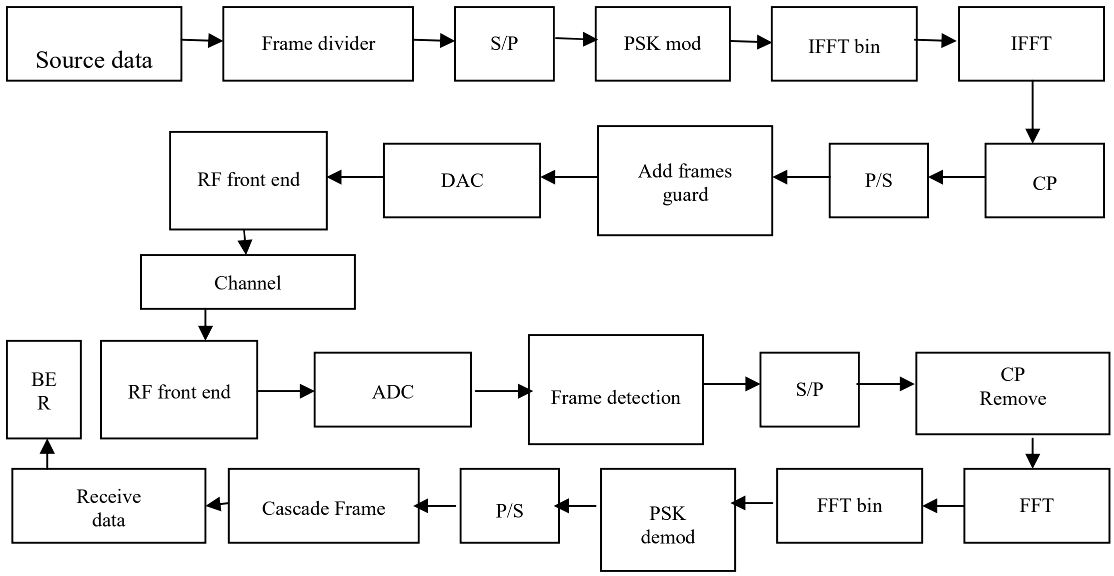


Figure 1. OFDM system model

The above figure illustrates the simulation model of OFDM system where a user's choice input image as a binary data will be used as a source. The high data rate serial input bit stream is fed into serial to parallel converter to get low data rate output parallel bit stream. The data can then be modulated. In this simulation we use different PSK modulation. The modulated data served as input to IFFT that converts the frequency domain OFDM signal into time domain OFDM symbol. The cyclic prefix is added in each OFDM symbol which acts as a guard interval to protect the OFDM signals from Inter carrier Interference (ICI) and Inter symbol Interference (ISI). This can be done by copying a part of the signal and putting it at the beginning of the signal. All the OFDM symbols are taken as input to parallel to serial data. These OFDM symbols constitute a frame. A number of frames can be regarded as one OFDM signal. This OFDM signal is allowed to pass through digital to analog converter (DAC). In DAC the OFDM signal is fed to RF power amplifier for transmission. Then the signal is allowed to pass through channel. At the receiver part, the received OFDM signal is fed to analog to digital converter (ADC) and is taken as input to serial to parallel converter. In these parallel OFDM symbols, Guard interval is removed and it is allowed to pass through Fast Fourier transform (Ahmed*et.al.* 2014; Mir*et.al.* 2015). Here the time domain OFDM symbols are converted into frequency domain. After this, it is demodulated and finally the low data rate parallel bit stream is converted into high data rate serial bit stream which is in form of binary. After this we calculate bit error rate (BER) and phase noise for different value of SNR.

a) Bit Error Rate (BER): A bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula:

BER = number of errors / total number of bits sent.(1)

As an example, assume this transmitted bit sequence: 0 1 1 0 0 0 1 0 1 1, and the following received bit sequence: 0 0 1 0 1 0 1 0 0 1

The number of bit errors (the underlined bits) is in this case 3. The BER is 3 incorrect bits divided by 10 transferred bits, resulting in a BER of 0.3 or 30%

b) Signal to Noise Ratio (SNR): Signal-to-noise ratio is defined as the power ratio between a signal (meaningful information) and the background noise (unwanted signal). It can be represented by the below relationship:

$$SNR= P_{signal}/P_{noise} \quad (2)$$

Where P is average power. Both signal and noise power must be measured at the same and equivalent points in a system and within the same system bandwidth. If the signal and the noise are measuredacross the same impedance, then the SNR can be obtained by calculating the square of the amplitude ratio.

$$SNR= P_{signal}/P_{noise}=(A_{signal}/A_{noise})^2 \quad (3)$$

Where A is root mean square (RMS) amplitude (for example, RMS voltage). Because many signals have a very wide dynamic range, SNRs are often expressed using the logarithmic decibel scale. In decibels, the SNR is defined as

$$SNR_{dB} = 10\log_{10}(P_{signal}/P_{noise}) = P_{signal,dB} - P_{noise,dB} \quad (4)$$

Which may equivalently be written using amplitude ratios as

$$SNR_{dB}=10\log_{10}(A_{signal}/A_{noise})^2=20\log_{10}(A_{signal}/A_{noise}) \quad (5)$$

c) Phase Error

During the OFDM demodulation, before being translated into symbol valuesthe received phase matrix is archived for calculating the average phase error, which isdefined by the difference between the received phase and the translated phase for thecorresponding symbol before transmission.

SIMULATION RESULTS

The performance of the employed system model is analyzed through Matlab simulation. After implementing the system model the following simulation results are found which are described below.

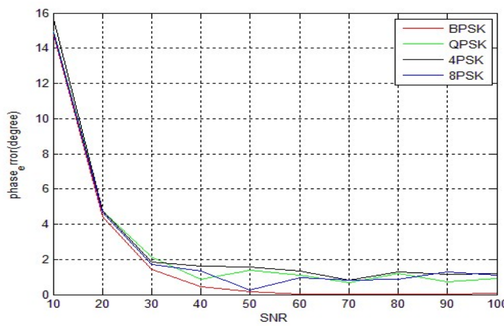


Figure 2. Phase Error with respect to SNR for BPSK, QPSK, 4PSK,8PSK

Figure 2 shows Phase Error verses SNR performance analysis of BPSK, QPSK, 4PSK and 8PSK modulation technique over Additive White Gaussian Noise channel. From this figure it can be seen that when SNR is10, Phase Error of BPSK is 14.75^o, QPSK is 14.93^o, 4PSK is 15.60^o and 8PSK is 14.90^o. Moreover if SNR is changed to 100, Phase Error for BPSK is 0.01^o, QPSK is 0.90^o, 4PSK is 1.21^o and 8PSK is 1.11^o. So, the behavior of phase error is seen to decrease in all modulation technique with the increase of SNR. Furthermore phase error reduction of OFDM system for BPSK modulationismuchbetter than QPSK, 4PSK & 8PSK and this result is almost same in all channels. When the number of subcarrier increases the phase error will also be changed in OFDM system. The phase error for increasing the number of subcarriers and M-PSK modulation is shown in Figure 3.

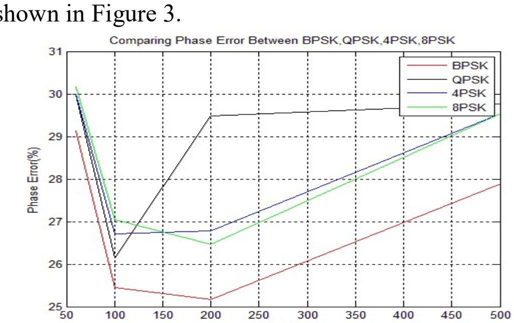


Figure 3. Phase Error for different subcarrier in case of BPSK, QPSK, 4PSK and 8PSK

From the above figure it can be seen that when the number of subcarrier is 60 the phase error for BPSK is 29.18%, QPSK is 30.45%, 4PSK is 29.98% and 8PSK is 29.67 %. On the other hand, if the number of subcarrier is increased to 100, the phase error decreases dramatically and after that it changes spontaneously. But in all cases, though the number of subcarrier increases, BPSK produces the best result for phase error reduction. To prove the efficacy of the employed best modulation technique Bit error rate is also analyzed. The Figure 4 shows the changes of BER with respect to SNR for MPSK modulation.

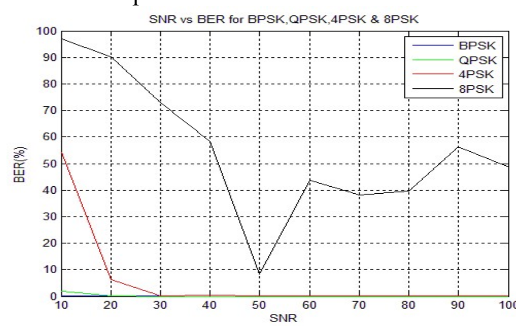


Figure4. BER with respect to SNR for BPSK, QPSK, 4PSK, 8PSK

The above figure illustrates BER vs. SNR performance analysis of BPSK, QPSK, 4PSK and 8PSK modulation technique over Additive White Gaussian Noise channel. From this analysis it can be seen that BPSK has lower BER than QPSK, 4PSK and 8PSK. For example when SNR is 10, BER for BPSK is 0.1980%, QPSK is 2.01%, 4PSK is 54.14% and 8PSK is 96.87%. Furthermore when SNR is100 BER for BPSK is 0.00%, QPSK is 0.00%, 4PSK is 0.01% and8PSK is 48.83%. If BER decreases, the performance of OFDM system will be increased. So, from the performance analysis of the above figure it can be clearly seen that among all MPSK modulation, BPSK modulation performs the best result for BER reduction in OFDM system.The below figure demonstrates the changes of pixel error with respect to SNR.

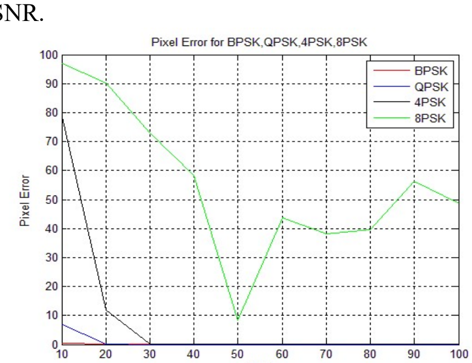
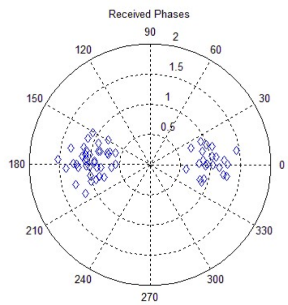
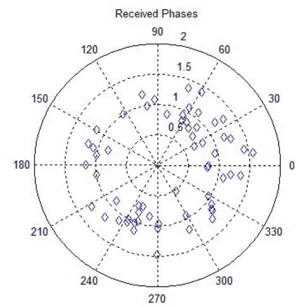


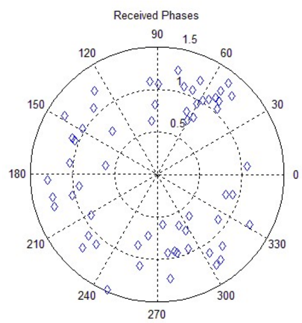
Figure 5. Pixel Error verses SNR for BPSK, QPSK, 4PSK, 8PSK

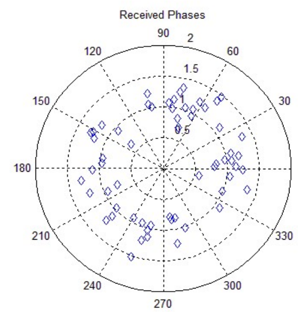
Figure 5 shows the changes of pixel error with respect to SNR and MPSK modulation. BPSK has lower Pixel Error than QPSK, 4PSK and 8PSK. From the above figure it can be seen that when SNR is 10, pixel error for BPSK is 0.500%, QPSK is 6.76%, 4PSK is 78.63% and 8PSK is 96.87%.Similarly if the value of SNR is increased to 100 the pixel error will be changed according to the previous rate. So, form this analysis it can be clearly seen that BPSK reduces pixels error more efficiently than any other MPSK modulation techniques.





(a) BPSK (b) QPSK



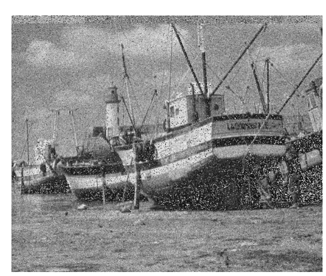


(c)4PSK (d)8PSK

Figure 6. Phase noise for MPSK and 10SNR

Figure 6 demonstrates the phase noise effect in OFDM system at MPSK modulation when the value of SNR is 10. So, Form the scatter plot of the above figure it can be seen that BPSK modulation can reduce the phase noise more significantly than any other modulation technique which coincides all the previous results of this research. The image quality of the received image with respect to transmitted image for different values of SNR are shown in the below figures.

(a) Original Image (b) BPSK



(c) QPSK (d) 4PSK (e) 8PSK

Figure 7. Image Quality of Received Image verses Transmitted Image for SNR=5


(a) Original Image (b) BPSK



(c) QPSK (d) 4PSK (e) 8PSK

Figure 8. Image Quality of received Image verses transmitted image for SNR=10




(a) Original Image (b) BPSK

(c) QPSK (d) 4PSK(e) 8PSK

Figure 9. Image Quality of received image verses transmitted image for SNR=20

Figure 7, Figure 8 and Figure 9 illustrates the original image and the received images for MPSK modulation with varied SNR. For lower SNR, the bit error rate is high and the received image is observable but not clear. But when we increase the SNR gradually, the bit error rate decreases and the received image quality is gradually increased. By comparing MPSK modulation technique, it can be seen that the BPSK has better bit error rate performance and better image quality than other QPSK, 4 PSK and 8 PSK.Constellation diagram is also analyzed in this research.

CONCLUSIONS

This paper carried out a performance analysis of OFDM system base on MPSK modulation to find out the best modulation technique for reducing phase noise. The simulation results show that by using BPSK modulation phase noise can be significantly reduced. Moreover by increasing the number of subcarrier BPSK modulation produces the same result for phase noise reduction. To prove the efficiency of the employed best modulation technique BER and pixel error rate is also analyzed and compared which coincides the previous results. A high quality image is used as an input of the source data, modulates this image by using MPSK modulation and compared for different SNR. Constellation diagram is also analyzed. Form all this analysis it can be clearly mentioned that BPSK modulation can reduce not only the phase noise but also the BER and pixel error rate more efficiently and effectively than others.

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