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EPerformance Comparison of Various Modulation Techniques in Wcdma System

R. Dhivya, N.R. Raajan and M. Pradeepa

Department of Electronics and Communication Engineering,
Sastra University, Thanjavur, India

Abstract: In Universal Mobile Telecommunication System (UMTS), high data rate transmission is possible by using Wideband Code Multiple Access technique (WCDMA) as an air interface. This paper studies performances of various modulation schemes such as Phase Shift Keying(both BPSK and QPSK) and M-ary Quadrature Amplitude Modulation (M-ary QAM) in WCDMA downlink transmission to improve its data rate. Based on Bit Error Rate (BER), performances of various modulation schemes have been investigated. The Simulation tool SIMULINK is used to evaluate BER in WCDMA system.

Key words: WCDMA · QAM · QPSK · BPSK · BER

INTRODUCTION

Universal Mobile Telecommunication System (UMTS) uses Wideband Code Division Multiple Access (WCDMA) as the platform for 3G cellular network. High data rate communication is possible by using WCDMA system, which results in efficient transfer of video streams and high resolution pictures to the end users. It hence becomes necessary to choose a suitable modulation technique as well as error correcting mechanism to be used in WCDMA. In 2G communication system Gaussian Minimum Phase Shift Keying (GMSK) is widely preferred which delivers data at the rate of 1 bit per symbol [1]. It could not deliver high data rate needed for video streaming and high resolution picture transfer, hence there is a necessity to switch over to other modulation schemes which could deliver much higher data rate. However, implementation of modulation techniques that provide high data rate requires modulators, filters, error detecting and correcting blocks and demodulators which are quite difficult to achieve. Here performance of modulation schemes such as BPSK, QPSK and QAM are studied.

System Model: The various steps performed in coding and multiplexing are Channel coding, Rate matching, Multiplexing two channels, Segmentation and mapping of physical channels. Figure 1 shows the system model.

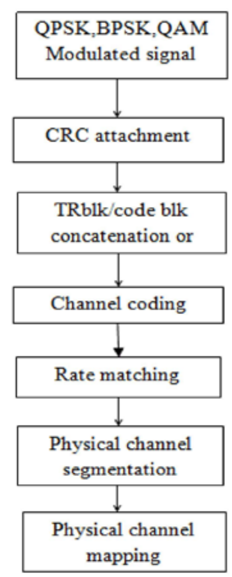

Fig. 1: System model

CRC Attachment: Cyclic Redundancy Check provides error detection on transport block. CRC bits are 24,16,12,8 and 0[2]. Parity bits are used to detect errors and they are generated by the polynomials given below.

$$P(24) = F^{24}+F^{23}+F^{6}+F^{5}+F+1$$
$$P(16) = F^{16}+F^{12}+F^{5}+1$$
$$P(12) = F^{12}+F^{11}+F^{3}+F^{2}+F+1$$
$$P(8) = F^{8}+F^{7}+F^{4}+F^{3}+F+1$$

Corresponding Author: R. Dhivya, Department of Electronics and Communication Engineering,
Sastra University, Thanjavur, India.

Channel Coding: Different types of coding used in WCDMA are Convolutional coding and Turbo coding. Channel coding is usually done to remove errors when they exceed beyond a particular level [2]. Hence, Channel coding with source coder provides efficient noise cancellation. The Channel decoder performs task of detecting and correcting bit errors. Here Dedicated Channel (DCH) is used and to encode this Convolutional coding of rate either ½ or 1/3 can be used.

Rate Matching: Rate matching is defined as the process of puncturing or repeating data bits to ensure that data rate after multiplexing is identical to channel bit rate of DPCH. Rate matching attributes are needed only when number of bits punctured or repeated are to be calculated [2, 3].

Channelization Codes: Channelization codes are being used to differentiate different users sharing the same physical channel. Here in order to suppress interference Orthogonal Variable Spreading Factor (OVSF)code is applied.In [8] they have used different sets of spreading codes for considerable performance improvement.

Signal to Noise Ratio: SNR is defined as the ratio of signal power to noise power level. It is expressed in Decibel (dB). *SNR=10log*$_{10}$*(signal power/ noise power)*

Bit Error Rate: Bit Error Rate is defined as the number of bits wrongly transmitted to total number of bits transmitted. It is usually expressed in percentage.

Eb/No Ratio: This can be defined as Energy per bit to Noise spectral density. It is called as *normalized SNR* and usually represented as "SNR per bit".

Modulation Techniques: The main objective of moving from 2G service to 3G service is to offer high data rate signal so that it is capable of transferring multimedia contents efficiently even over noisy channel. This can be done by selecting suitable error correcting as well higher order modulation schemes. The various types of modulation schemes discussed here are Phase Shift Keying (BPSK and QPSK) and Quadrature Amplitude Modulation (QAM).

BPSK: BPSK is the most simplest form of Phase Shift Keying (PSK). The phase of the signal is being shifted and they are separated by 180 degrees.

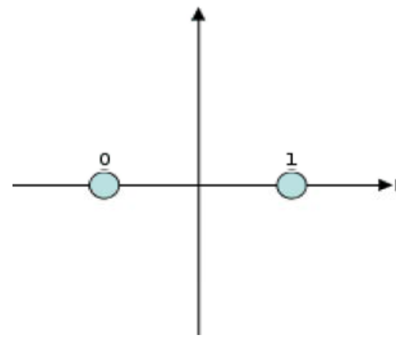

Fig. 2: Constellation diagram for BPSK

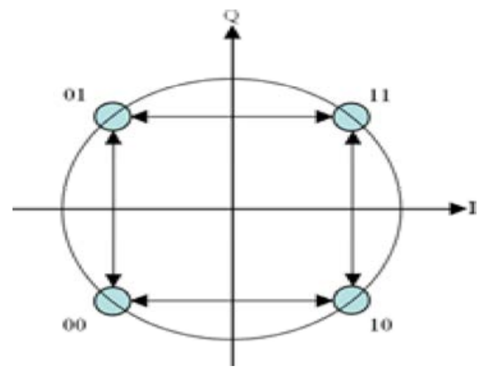

Fig. 3: Constellation diagram for QPSK

Hence it is also known as 2-PSK. Its Constellation diagram is shown below and it is here drawn on real axis 0°and 180°. This type of modulation is more robust and best suited for the case of providing secure communication. However it has a flaw that it can modulate signal at the rate 1bit /symbol so it is not much suited for high data rate communication. BPSK signal is represented by the following equation.

$S_n(t)=\sqrt{(2Eb/Tb}$ Cos ($2\Pi f_c$+?(1-n))Where n=0,1,…f_c is the frequency of carrier wave. Figure 2 depicts the constellation figure for BPSK.

QPSK: QPSK is a digital modulation technique and it is called as higher order PSK modulation. It modulates data at the rate of 2bits per symbol hence, it can achieve higher data rate compared to BPSK modulation. Here, phase of the carrier is shifted to 0, π /2, π , 3 π /2. This is used to indicate four states of two bit binary code and each state of these carriers is referred as Symbol. It is represented by the equation

$S_n(t)=\sqrt{(2Es/Ts}$ Cos (2 π fct+ (2n-1) π /4) Its constellation diagram is given by figure 3.

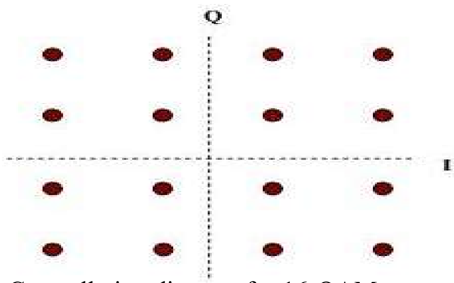

Fig. 4: Constellation diagram for 16-QAM

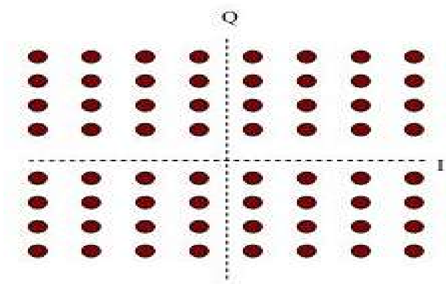

Fig. 5: Constellation diagram for 64-QAM

QAM: QAM can be viewed as the combination of both Phase Shift Keying (PSK) and Amplitude Shift Keying (ASK) or of Phase Modulation and Amplitude Modulation. Here both the amplitude as well as phase of the carrier are changed to represent data signal. Carrier is 90° out of phase with each other. Figure 4 shows constellation diagram of 16-QAM and figure 5 for 64-QAM.

RESULTS

Based on the data available from performance of W-CDMA system using QPSK,BPSK and QAM modulation schemes the Bit Error Rates are obtained. BER, SNR and the total no of errors are tabulated in table 1.

The simulation is done in Simulink. BER is high for 16-QAM comparing with QPSK when noisy channel is used. Improvement in both Eb/No and BER are obtained by using 16-QAM compared to QPSK at the order of 10^{-3} [6]. Performance of both QPSK and QAM degrades as the noise level increases [4, 6].

Table 1: Result for BER vs. SNR

Signal to Noise Ratio(SNR)	No of errors	Bit Error Rate(BER)
0	15615	7.806500e-002
1	11345	5.66500e-002
2	7515	3.765000e-002
3	4479	2.235000e-002

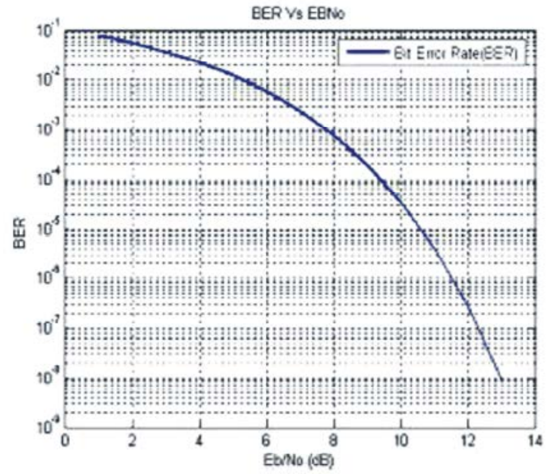

Fig. 6: BERvsEb/No in WCDMA system.

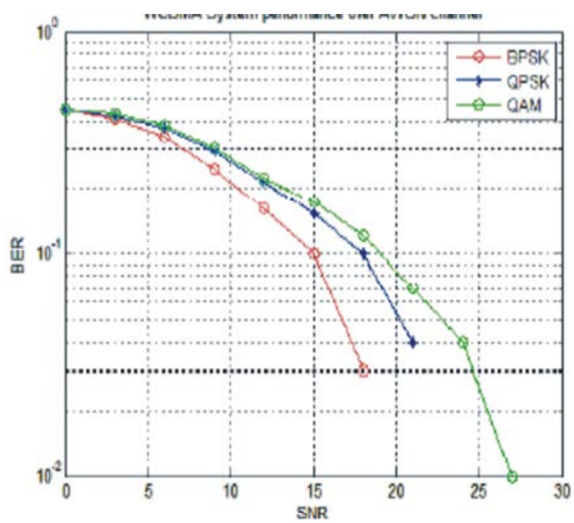

Fig. 7: Comparison of BPSK,QPSK,QAM ie.,BER vs. SNR

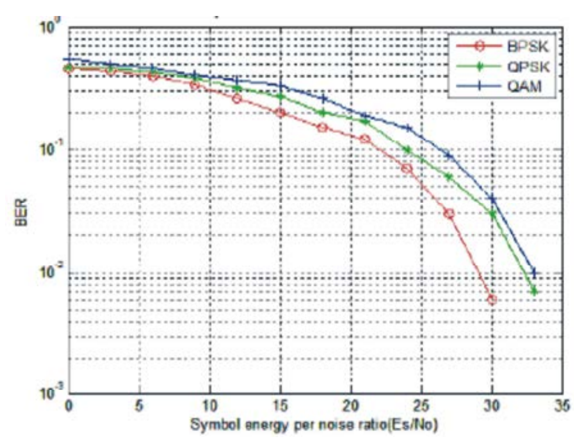

Fig. 8: Comparison of BPSK,QPSK,QAM ie.,BER vs. Eb/No

The theoretical plot for BER versus Eb/No is shown in figure 6. This figure 7 shows the graph that compares BER of different modulation techniques such as BPSK,QPSK and QAM. Though the data rate increases with higher order modulation schemes, they exhibit higher error rate too. To achieve a higher data rate, it is observed that a decrease in BER value is required for an increment in SNR value which is significantly done by using QAM compared to QPSK and BPSK.

Figure 8 shows the performance of various modulation techniques based on BER vs Eb/No. From this figure it has been interpreted that QAM has highest BER than QPSK and BPSK but still it is used to achieve higher data rate.

CONCLUSION

The main challenge in telecommunication field is to achieve high data rate efficiently with smaller Bit Error Rate. Analyzing the results obtained from simulation, it is found that the performance of QAM in noisy environment is higher compared to QPSK and BPSK and efficiently higher data rate is also achieved.

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