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Improving Quadrature Amplitude Modulation (16QAM) Performance in Wide band Code Division Multiple Access using Convolutional Coding

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ABSTRACT

The performance of 16 QAM modulation techniques has been analyzed and improved for Wide band Code Division Multiple Access (WCDMA) applications at variable data rate. Matlab and Simulink have been used in the evaluation and the BER with and without coding has been compared as the data rate was increased from 64 kbps to 2MBps. It has been concluded that when convolutional coding was applied, the BER has could be improved by 0.54 % at 64 kbps, 0.39 % at 144 kbps, 0.78 % at 384 kbps and 0.53% at 2 MBps, all this being compared to a communication system without coding. Thus we can enhance the performance of a 16 QAM modulations by convolutional coding**.**

Keywords: *BER, modulation, convolutional, coding, WCDMA*

1. INTRODUCTION

Tremendous growth in wireless communication has been necessitated by significant increase in subscribers and traffic, requiring increased bandwidth due to increased online gaming, music downloads, video streaming among other factors [1]. In response to this, wide band code division multiple access (WCDMA), a 3G mobile cellular wireless air interface technology was developed to provide for a global standard on real-time multimedia services. WCDMA is an improved version of CDMA, which is a multiple access technology, where users are separated by a unique code, thus enabling all users to use the same frequency, at the same time being able to transmit data. A 5 MHz wide radio signal is used with a chirp rate of 3.84 Mcps. Its main advantage is that it can support high data rate, has high spectrum efficiency and a high quality of service. The implementation of the WCDMA presents technical challenges chiefly because of its complexity arising from algorithms, requirement of perfect modulators, demodulators and filters among others. As a solution, higher order modulation format has been used as in [2] and [3] Modulation schemes which are capable of delivering more bits per symbol are more immune to errors caused by noise and interference in the channel. Moreover, errors can be easily produced as the number of users is increased and the mobile terminal is subjected to mobility. Thus, it has driven many researches into the suitable application of higher order modulations. W-CDMA systems can employ the high order modulation (MPSK or M-QAM) to increase the transmission data rate with the link quality control [1]. Thus in this work, we analyse the margin expressed as a percentage by which we can improve the BER in a WCDMA 16-QAM modulation format, in an AWGN channel

2 RELATED WORK

1.1 QAM modulation

This is a modulation technique in which the amplitude of the signal is allowed to vary with phase. Hence, the scheme can be viewed as a combination of Amplitude Shift Keying (ASK) and Phase Shift Keying (PSK). The general form of M-ary QAM can be represented as [2];

$$S_i(t) = \sqrt{\frac{2E_{\min}}{T_s}} a_i Cos(2\pi f_c t) + \sqrt{\frac{2E_{\min}}{T_s}} b_i Sin(2\pi f_c t) \quad (1)$$

For $0 \le t \le T \quad and \quad i = 1,2,......M$

$E_{\min}$ Is the energy of the signal with the lowest amplitude integers chosen according to the location of that particular signal point.

In [3], a WCDMA system was developed and simulated using QPSK with and without error correction. The model was subjected to an interfering AWGN channel and the data rate was increased from 64 kbps to 2MBps. It was found out that convolutional coding was able to improve the bit error rate by 6.74% at 2MBps, 5.59% at 384 kbps and 5.32% at 64kbps. Thus convolutional coding improved the WCDMA performance at increased data rates. In [4], three digital modulation techniques performances namely; BPSK, QPSK and 16-QAM were analysed in WCDMA subjected to an AWGN and a Rayleigh fading channel. Primarily, it was noted that the performance of BPSK is better than the other two but as the number of users is increases, it performs poorly. QPSK has been found to have a good performance than QAM in a LOS, but however. In general, the reason that causes poor performance of W-CDMA system when the number of users increased is because the value of cross correlation between the codes is not 0 and thus it causes interference. Thus, it is suggested that high data rate modulation technique such as 16-QAM needs an error correction coding such as convolutional coding or turbo coding so that the interference from the adjacent carrier phase in the constellation of 16-QAM can be eliminated if not minimized BPSK and 64 QAM were analysed for WCDMA application in [5], in Rayleigh and Rician channels without any coding. It was concludes that these two modulation schemes generally performs better in a Rician than a Rayleigh channel, which agrees with theory. This study seeks to address the margin by which the BER performance of a WCDMA system employing a 16 QAM can be improved by convolutional error correction as the data rate is increased from 64 kbps to 2Mbps, which are the data rates

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specified for WCDMA. Sufficient literature [2, 6] show that 16-QAM performance degrades heavily as the data rate is increased, but its chief advantage is an increased data throughput compared to lower order modulations. Hence the application of a coding scheme in this study.

2.0 METHODOLOGY

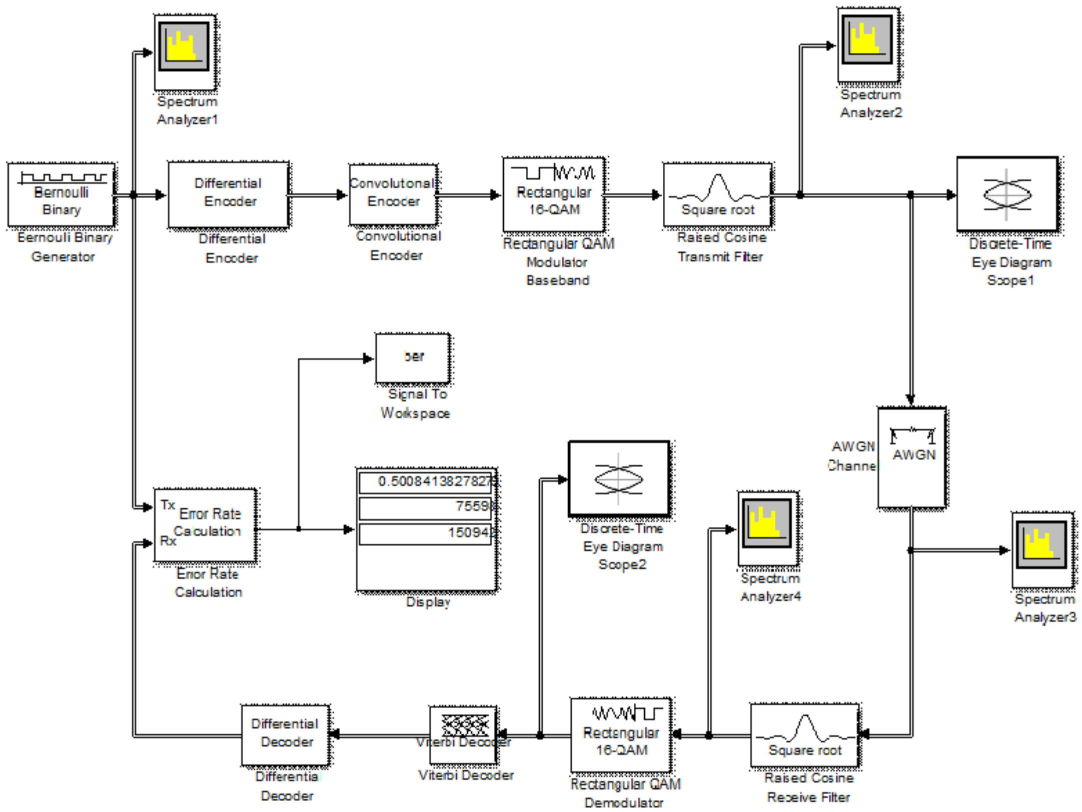

Fig 1: Simulation set up

The simulation was carried out in Matlab/ Simulink and the arrangement of the various blocks is as shown in Fig 1 below. The Bernoulli binary generator is used as the data source with a probability of 0.5 for either a 1 or a 0. The data rate is varied in this block, since sampling time is equal to the inverse of the data rate. The data generated by the Bernoulli binary generator is differentially encoded by the differential encoder, which produces a sequence of binary output vectors.

Convolutional Encoder It encodes a sequence of binary input vectors to produce a sequence of binary output vectors and it can process multiple symbols at any given time. It is specified by the Trellis structure parameter which includes constraint length, generator polynomials and the feedback connection polynomials. This is done with the *poly2trellis* command which located in the Trellis structure field of the encoder in Simulink.

Raised Cosine Transmit Filter is used to up-samples well as filtering the input signal using a normal raised cosine FIR filter or a square root raised cosine FIR filter. For this system model the square root raised cosine filter is used in the transmitter and receiver section. The QAM modulator modulates the signal using quadrature amplitude modulation. A QAM demodulator is also included in the receiver to demodulate these signals.

The Virtebi was used in decoding information that was coded by the convolutional encoder in the transmitter. Therefore it uses the same Trellis structure as in the transmitter. It can process multiple input symbols at any given time for a faster performance of the system. The decoder is also specified by the trellis structure parameter, decision type, trace back depth and operation mode. The error rate calculator is used to evaluate the bit error rate of the system by comparing the

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input data from the transmitter and that from the receiver. The bit error rate is equal to the number of bit received at the receiver in error divided by the total number of bits that have been transmitted.

3.0 RESULTS

Fig 2: User information

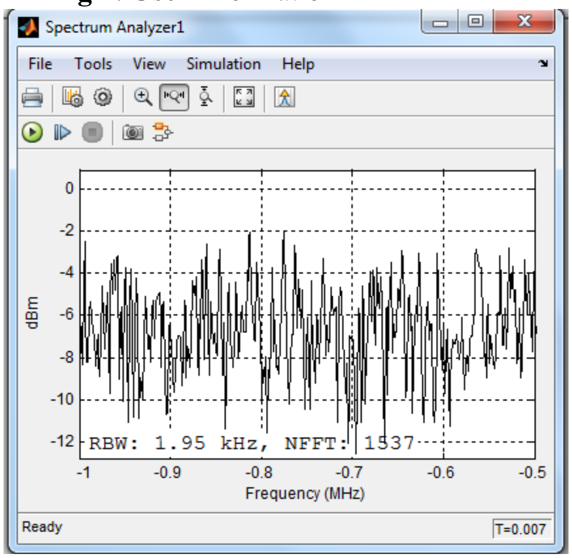
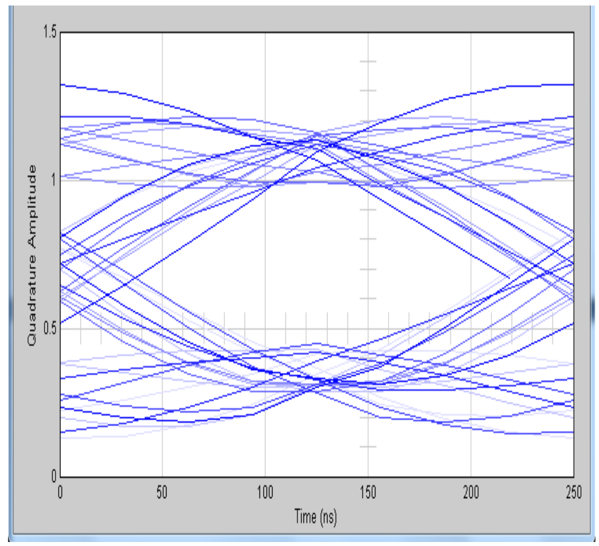
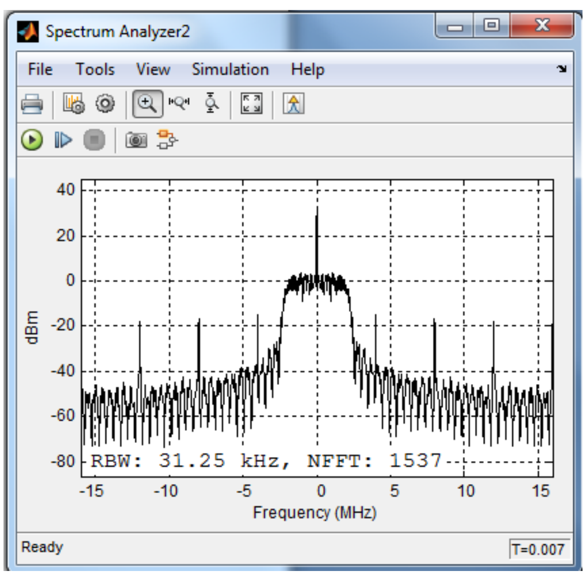


Fig 3: Modulated signal





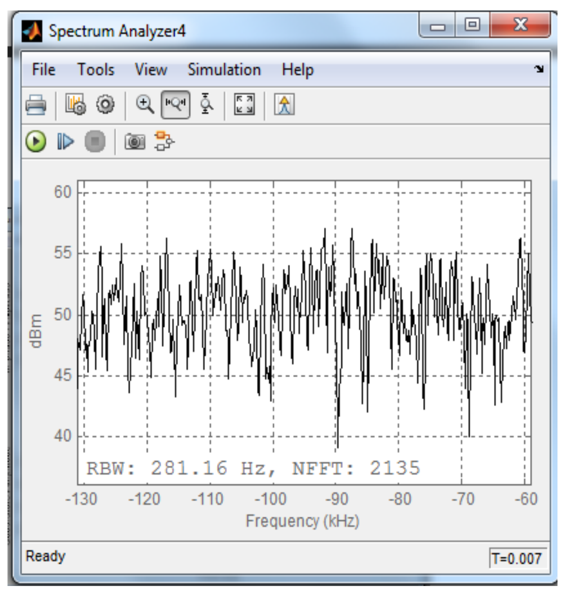


Fig4: Transmitted signal

Fig 5: Noise corrupted signal

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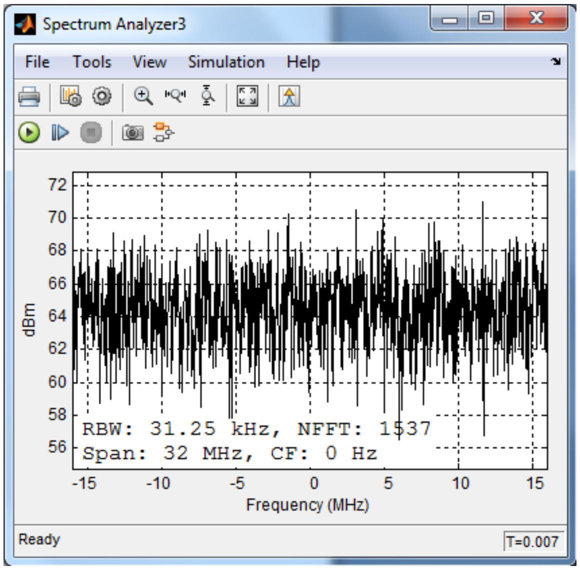

Fig 6: Noise filtered signal

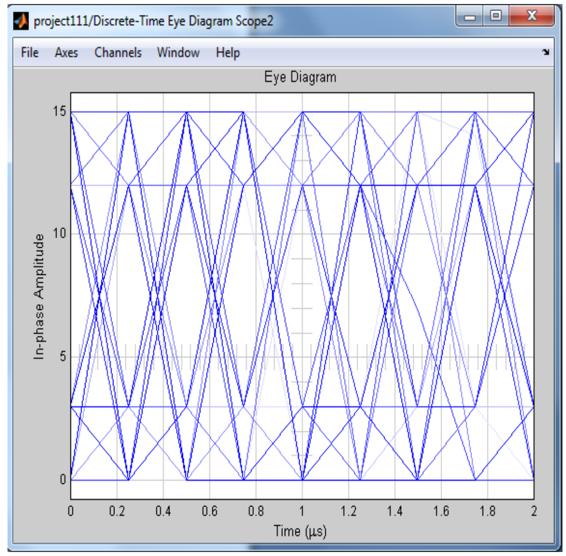

Fig 7: Demodulated signal

Table 1: Comparison of bit error rates with and without coding

User data (bps)	*BER without coding*	*BER with coding*	*% change*
64 k	0.497909	0.495221	0.54
144 k	0.498058	0.496130	0.39
384 k	0.498231	0.494339	0.78
2Mb	0.499002	0.496351	0.53

4.0 DISCUSSION AND CONCLUSION

Table I above shows the BER values of the WCDMA system at different data rates with and without convolutional coding. The error rate block had to stop the simulation when 10^8 bits were transmitted or 10 000 errors were encountered. It can be observed that with 16 QAM modulations in WCDMA, the performance can be improved by 0.54 % at 64 kbps, 0.39% at 144 kbps, and 0.78 % at 384 kbps and by 0.53% at 2Mbps. Hence the role that the error detection and compensation plays in improving the quality of service in a WCDMA system is inevitable.

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