3G WCDMA Physical Layer

Gian Angelo Tria
ECE 404:Wireless Communications
The Cooper Union
New York City, USA
gianangelotria@gmail.com

***Abstract*—The objective was to implement some of the basic properties present within a 3G WCDMA physical layer for the downlink. The parts of WCDMA that were chosen to be recreated are the scrambling codes, OVSF codes, and QPSK. These were tested on a binary code and tested by first encoding and modulating the data. Then the data was passed through a AWGN channel before being decoded and demodulated. Bit error rates and scatter plots were used to observe the effects of the noise through the encoding and modulation schemes.**

***Index Terms*—WCDMA,Scrambling Code, OVSF, QPSK, AWGN**

I. Introduction

In order to demonstrate Wideband Code Division Multiple Access (WCDMA), the focus was placed on the modulation scheme and the encoding schemes. The data was encoded in two different ways: scrambling codes and Orthogonal Variable Spreading Factor (OVSF) code, then Quadrature Phase Shift Keying (QPSK) was used to send the data through an Additive White Gaussian Noise (AWGN) Channel. The method in which these schemes were implemented will be discussed, and the effect of each of the channels will be shown through bit error rate calculations and scatter plots.

II. Data Creation

In order to simplify the data creation process, random bits of value 1 or 0 were used as the base data for this demonstration of WCDMA. This scheme can be scaled up to have more than two symbols with the only necessary changes regarding the use of the QPSK function that will be discussed later.

III. Scrambling Code

Scrambling Code is the first type of encoding that was done on the data. It utilizes a generator polynomial with initial conditions to generate a scrambling code that acts as a scrambling key for the data. The data can be thought of as passing through the generator polynomial with a certain rate, and with the scrambling code, this process is reversible. With the MATLAB scrambling function, the scrambling code takes the input data and scrambles it into random values within an intended range. For simplicity, the output values were chosen to be between 0 and one, but this could be changed to accommodate a wider variety of input and output signals.

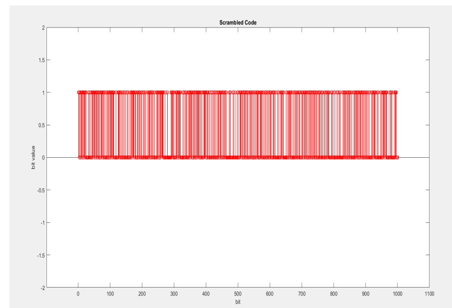

Fig. 1. Data after being processed by scrambling code

IV. OVSF Code

OVSF Code is the second type of encoding that was done on the data, and this OVSF represents the spreading technology that is characteristic of CDMA (Code Division Multiple Access). It generates an orthogonal code that perserves orthogonality according to a spreading factor and the number of samples per frame. Because the OVSF code only has values of -1 and 1. A function was used to convert the 0's and 1's of the scrambled code into -1's and 1's respectively. The OVSF code was created using MATLAB's Communications toolbox, but then it had to be extended so that it could be applied to the scrambled code. Notice that the code is now of only values -1 and 1 in Figure 2. Another factor of the OVSF code to note is that the spread code and repeats in the code contributes to a better bit error rate. As long as over half of the samples per frame are correct for each bit, the error will be corrected.

V. QPSK and AWGN

QPSK was used to modulate the signal before passing it through an AWGN channel. Because there were only two distinct symbols present, the QPSK had two areas of symbols that had a 180 degree phase shift from each other, but if the number of symbols were n, they would need to be spaced equidistantly with phase shift of 360/n between each different symbol. In order to implement the QPSK, a function was made that utilized the function QPSK modulation and demodulation from the Communications toolbox in MATLAB. The results can be seen in Figures 3 and 4 for differing SNR values. It can be seen in Figure 4 that with a good SNR ratio, it is possible to distinguish the symbols from each other, while in

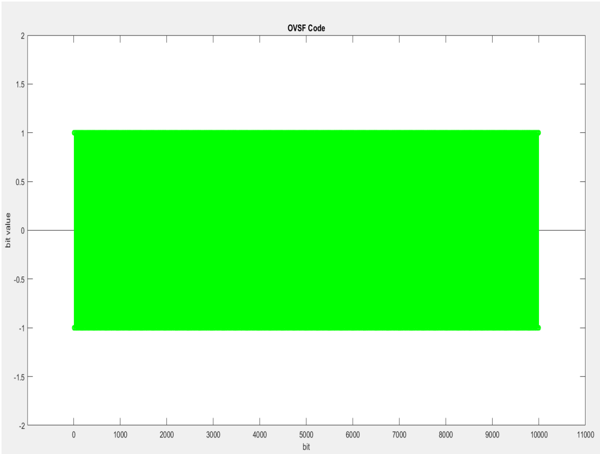

Fig. 2. Data after being processed by OVSF code

Figure 3, the noise is so large that the noise clouds intersect, contributing to a much higher bit error rate.

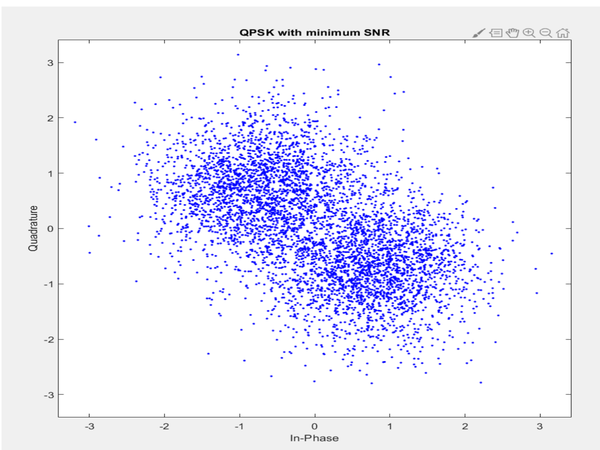

Fig. 3. Scatter plot of the data after QPSK with .1 SNR

VI. Analysis

In order to analyze how well the downlink worked with two different types of encoding and modulation before an AWGN channel, a bit error rate was computed for each SNR between .1 and 10 as seen in Figure 5. Although the bit error rate looks very high with an SNR of .1, it is important to notice that this is only around a 3 percent bit error rate. Also, the bit error rate flattens at 0 before an SNR of 4. With no error control, the bit error rate already seems sufficient, but it can be improved with this scheme by having a larger number of samples per frame. This gives freedom to experiment between the number of bits being sent through and the bit error rate.

VII. Improvements

Within WCDMA the uplink and downlink are slightly different, with a notable difference being a Dual Channel QPSK for for the uplink. Experimenting with the control code of the Dual Channel QPSK would be one of the first

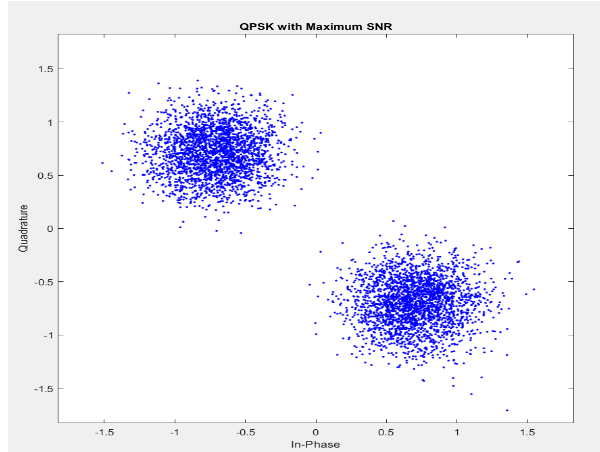

Fig. 4. Scatter plot of the data after QPSK with 10 SNR

additions I would make as I am not sure what effect this would have on the bit error rate if the control channel was working properly.Additionally, experimenting with a much higher number of bits per symbol for QPSK would have worsened the bit error rate, and this would have given the need for error control coding. Seeing the effect of error control algorithms in addition to the modulation and encoding schemes to make an end to end communications link would have demonstrated the versatility of 3G further.

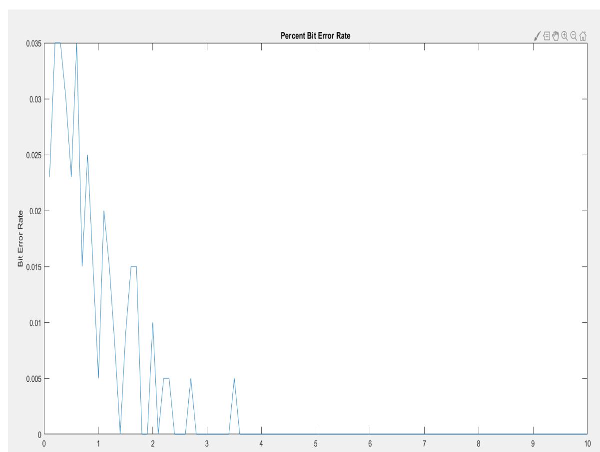

Fig. 5. Percent Bit Error rate of Downlink from .1 to 10 SNR

Acknowledgments

I would like to thank Armaan Kohli, Sophie Jaro, Nikita teplitskiy, and Kevin Jiang for helping me get started and explaining important concepts regarding the spreading and scrambling codes.

References

[1] M. Chowdhury, A. Alam , and T. Hult, "Study Comparison of WCDMA and OFDM"