Simulation Study of FIR Filter for Complexity Analysis in WCDMA

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Abstract: With the recent exploding research interest in wireless communications, the application of signal processing to this area is becoming increasingly important. Indeed, it is the advances in signal processing technology that make most of today's wireless communications possible and hold the key to future services. The present paper deals with simulation model of square root raised cosine pulse shaping filter for WCDMA with different parameters of the filter at 5Mhz.
Keywords: FIR Filter ,WCDMA, Simulation Model

1. Introduction

Wideband Code-division multiple access is one of several methods of multiplexing wireless users. In CDMA, users are multiplexed by distinct codes rather than by orthogonal frequency bands, as in frequency-division multiple access. The enhancement in performance is obtained from a Direct Sequence Spread Spectrum (DSSS) signal through the processing gain and the coding gain can be used to enable many DSSS signals to occupy the same channel bandwidth, provided that each signal has its own pseudorandom (signature) sequence [1-7]. Thus enable several users to transmit their information over the same channel bandwidth. This is the main concept of a WCDMA communication system. The signal detection is accomplished at the receiver side by knowing the code sequence or signature of the desired user. Since the bandwidth of the code signal is chosen to be much larger than the bandwidth of the information-bearing signal, the encoding process enlarges or spreads the spectrum of the signal. Therefore, it is also known as spread spectrum modulation. The resulting signal is also called a spread-spectrum signal, and CDMA is often denoted as spread-spectrum multiple access. A tradeoff exists between bandwidth containment in frequency domain and ripple attenuation in time domain. It is this tradeoff of bandwidth containment versus ripple amplitude which must be considered by design engineers, when developing a data transmission system that employs pulse shaping.

The application of signal processing techniques to wireless communications is an emerging area that has recently achieved dramatic improvement in results and holds the potential for even greater results in the future as an increasing number of researchers from the signal processing and communications areas participate in this expanding field.[1-5].From an industrial viewpoint also, the advanced signal processing technology cannot only dramatically increase the wireless system capacity but can also improve the communication quality including the reduction of all types of interference. To satisfy the ever increasing demands for higher data rates as well as to allow more users to simultaneously access the network, interest has peaked in what has come to be known as WCDMA The WCDMA has emerged as the most widely adopted 3G air interface and its specification has been created in 3GPP .In this system the user information bits are spread over much wider bandwidth by multiplying the user data bits with quasi random bits called as chips derived from CDMA spreading codes. In order to support very high bit rates (up to 2 Mbps) the use of variable spreading factor and multimode connection is supported. The chip rate of 3.84Mcps/sec is used to lead a carrier bandwidth of 5Mhz.WCDMA also supports high user data rates and increased multipath diversity[8].Here each user is allocated the frames of 10 ms duration during which the user data is kept constant though data capacity among users can change from frame to frame.

2. Need of Efficient Pulse Shaping

In communications systems, two important requirements of a wireless communications channel demand the use of a pulse shaping filter. These requirements are:

1) Generating band limited channels, and

2) Reducing inter symbol interference
(ISI) arising from multi-path signal reflections.
Both requirements can be accomplished by a pulse shaping filter which is applied to each symbol. In fact, the sync pulse, shown below, meets both of these requirements because it efficiently utilizes the frequency domain to utilize a smaller portion of the frequency domain, and because of the windowing affect that it has on each symbol period of a modulated signal.[9-10]

3. Pulse Shaping in WCDMA

Code-division multiple access is one of several methods of multiplexing wireless users. In CDMA, users are multiplexed by distinct codes rather than by orthogonal frequency bands, as in frequency-division multiple access. The enhancement in performance obtained from a direct sequence spread spectrum (DSSS) signal through the processing gain and the coding gain can be used to enable many DSSS signals to occupy the same channel bandwidth, provided that each signal has its own pseudorandom (signature) sequence. Thus enable several users to transmit there information over the same channel bandwidth. This is the main concept of a CDMA communication system. The signal detection is accomplished at the receiver side by knowing the code sequence or signature of the desired user. Since the bandwidth of the code signal is chosen to be much larger than the bandwidth of the information-bearing signal, the encoding process enlarges or spreads the spectrum of the signal. Therefore, it is also known as spread spectrum modulation. The resulting signal is also called a spread-spectrum signal, and CDMA is often denoted as spread-spectrum multiple access. The processing gain factor is defined as the ratio of the transmitted bandwidth to information bandwidth and is given by:
Gp=Bt/Bi.
Correlating the received signal with a code signal from a certain user will then only dispread the signal of this user, while the other spread-spectrum signals will remain spread over a large bandwidth.

4. Simulation Model for WCDMA

The WCDMA communication link proposed in this section is shown in Figure 1. The performance in terms of the Bit Error Rate can be examined for different values of Group Delay D of the pulse shaping filter against a sinusoidal interference. A simulink model based on the matlab 7.3 version will provide the output. The information signal in wideband CDMA system is generated by Bernoulli Binary Generator and the PN sequence is used for spreading the signal at 5 MHz bandwidth. The signal is passed from different parameters block as shown in figure 1 and at the end BER is calculated by comparing the transmitted data and received data. On the basis of above block diagram, a simulation model has been developed by using Matlab Simulink Library as shown in figure 2.

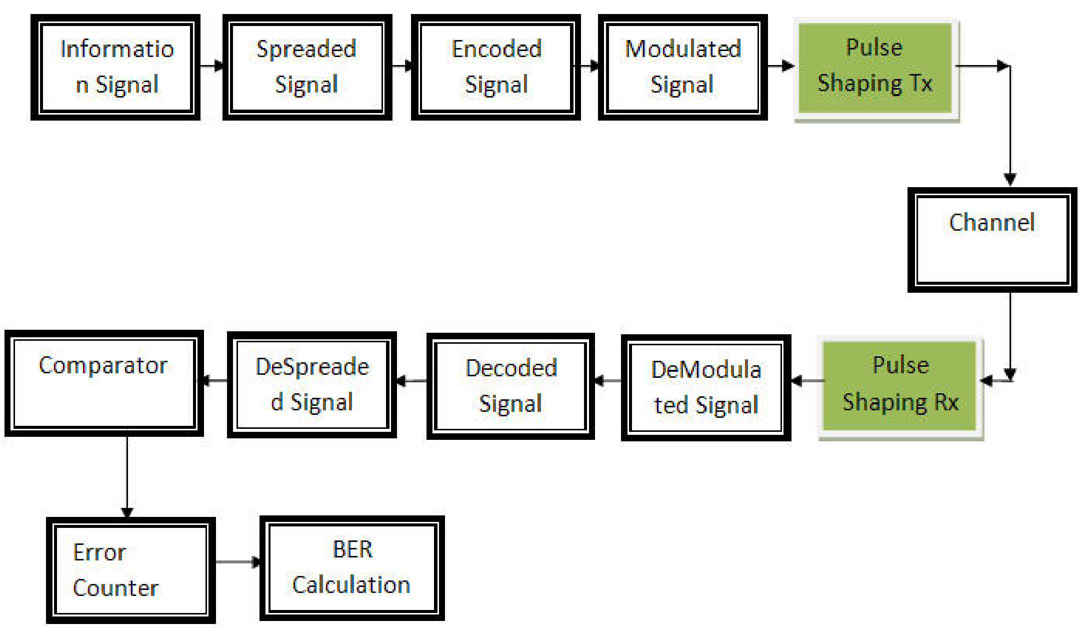

Figure 1. Block diagram for WCDMA System

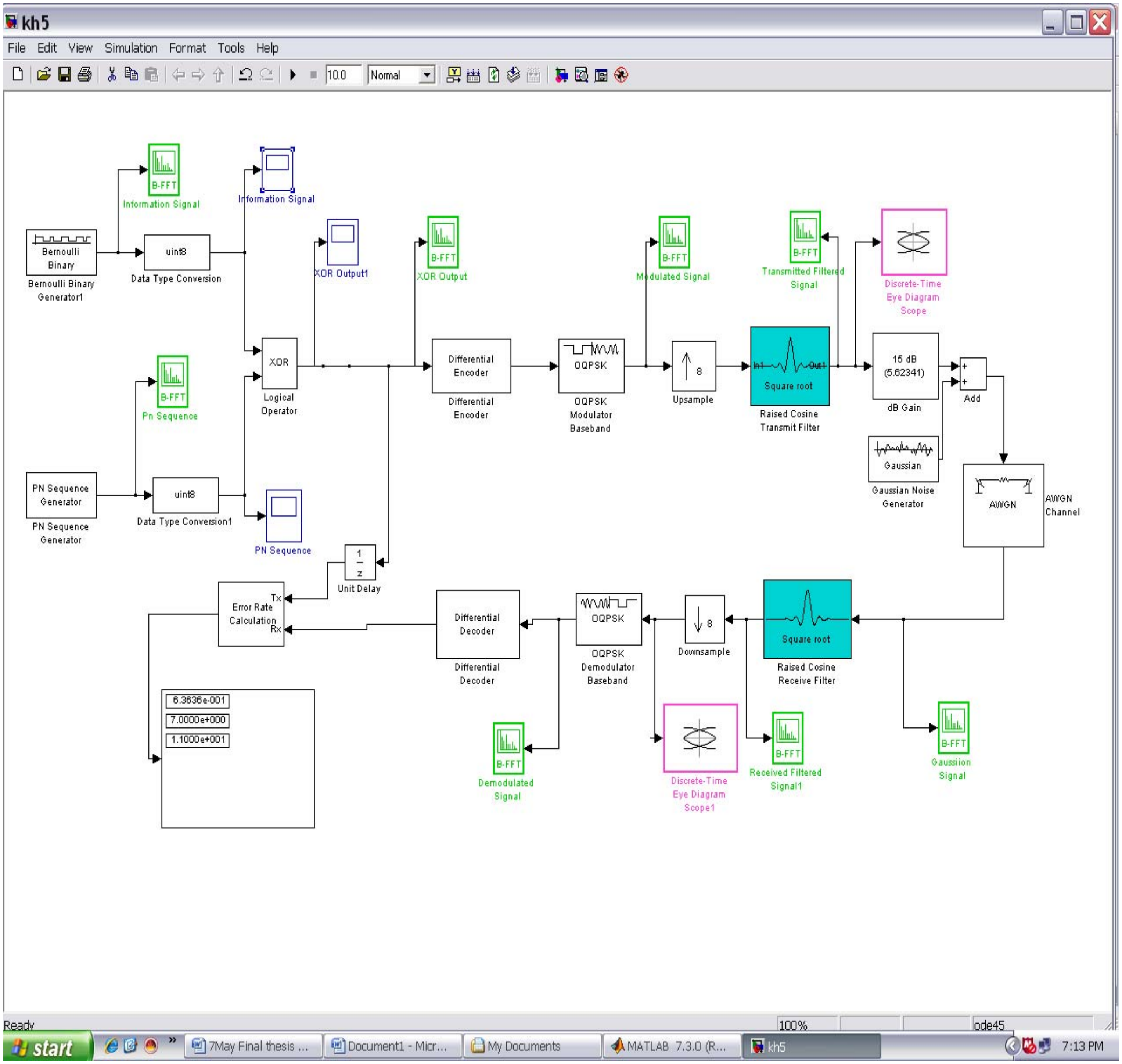

Figure 2.WCDMA based Simulation Model developed for Square Root Raised Cosine Pulse

5. Observations in Simulation Model:

Scope as viewed for Information Signal at Input Sample rate=1/64kbps and Scope as viewed for PN Sequence Generator at Sample Rate=1/3840Kbps are shown in figures 3 and 4 respectively.Figure 5 shows the Scope of XOR Output of Information Signal. BFFTs for Information Signal, PN Sequence Generator ,XOR Block output and Modulated Signal are shown in figures 6,7,8 and 9 respectively. BFFT scopes for Transmitted Filtered Signal, Received Filtered Signal, Discrete Time Eye Diagram and Demodulated Signal are shown in figures 10,11,12,13 respectively. The frequency contents of an input sequence are displayed at different stages of the blocks by Buffered FFT ,which acquires a sequence of input samples into a buffer and displays the magnitude of FFT. Amplitude values (Expressed in db) are scaled along y-axis. The frequency (plotted along x-axis) units are in khz.

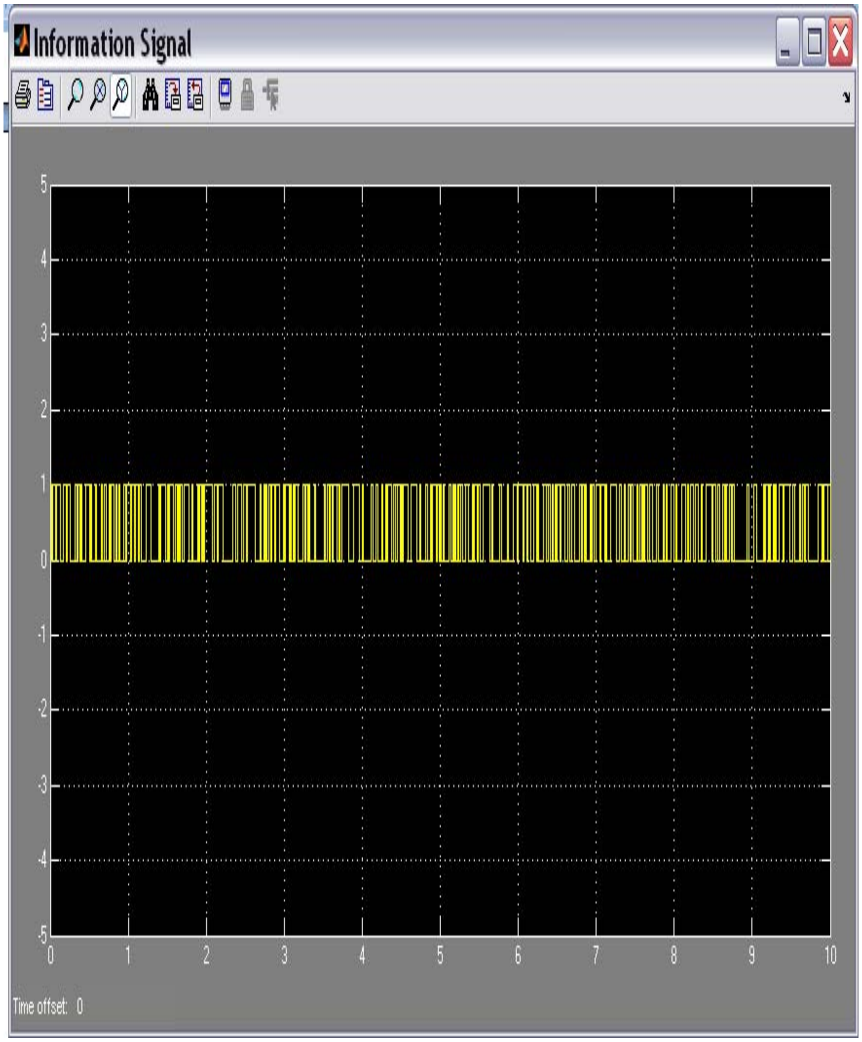

Figure 3. Information Signal

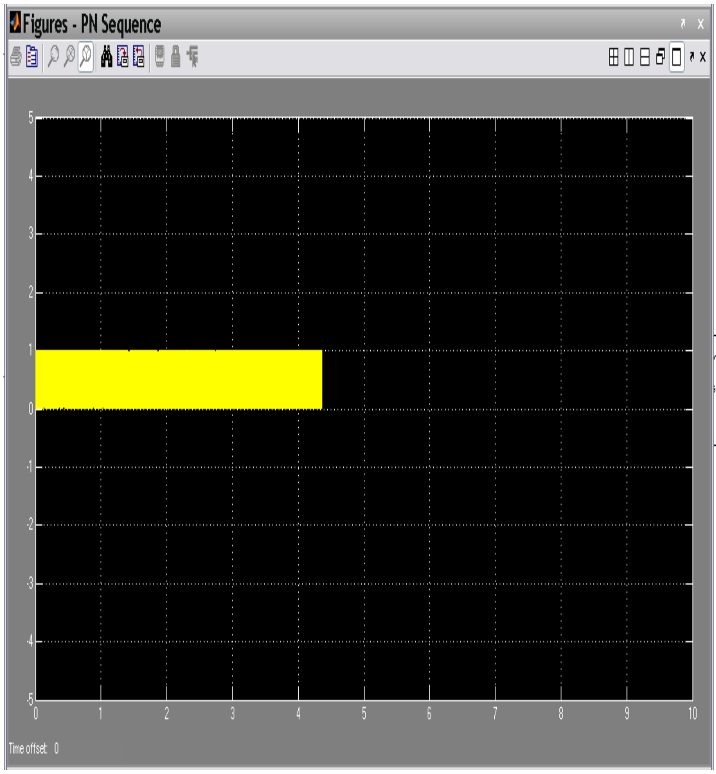

Figure 4.PN Sequence Generator Output

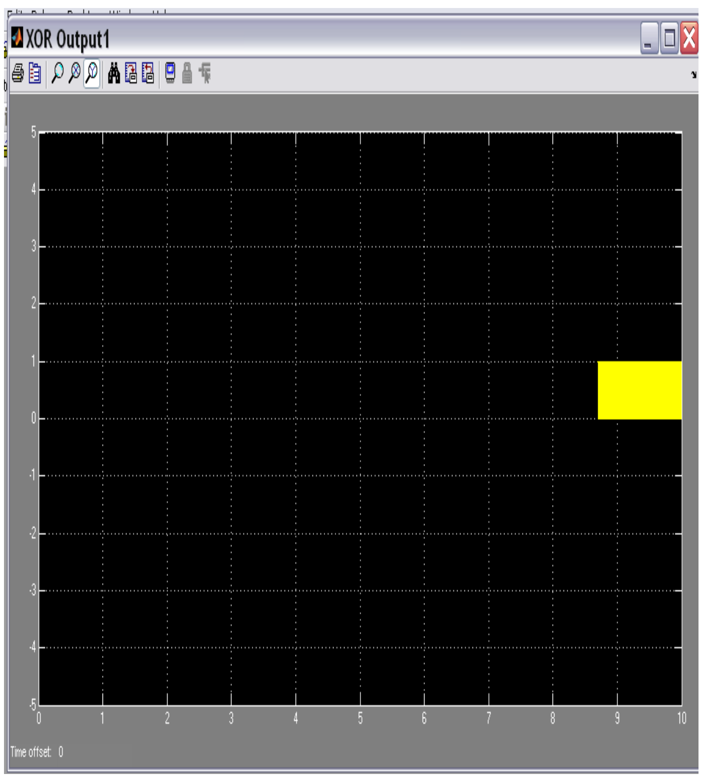

Figure 5. XOR Output

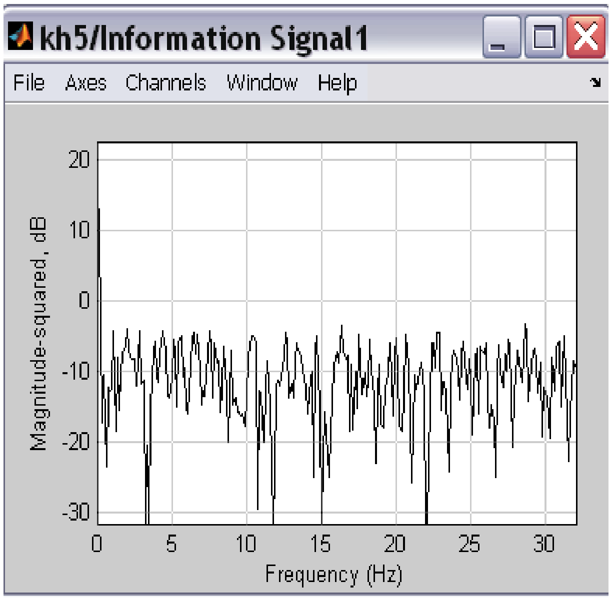

Figure 6. BFFT Scope output of Information signal

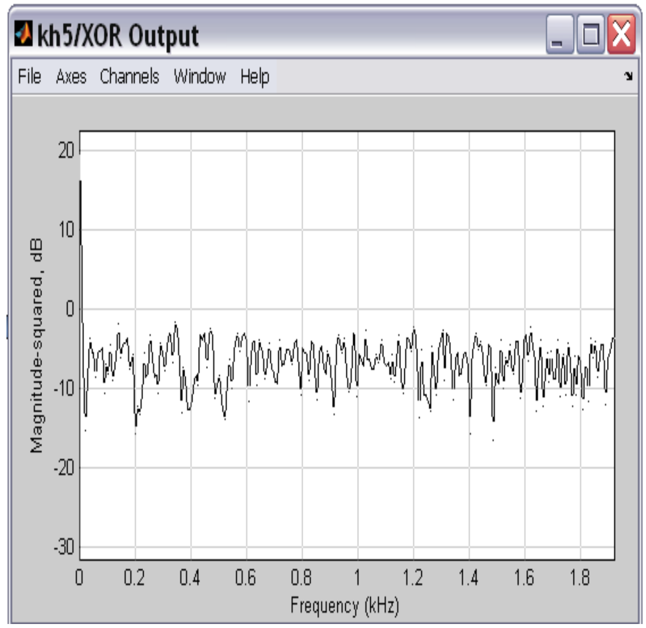

Figure 8.BFFT Scope output of XOR block

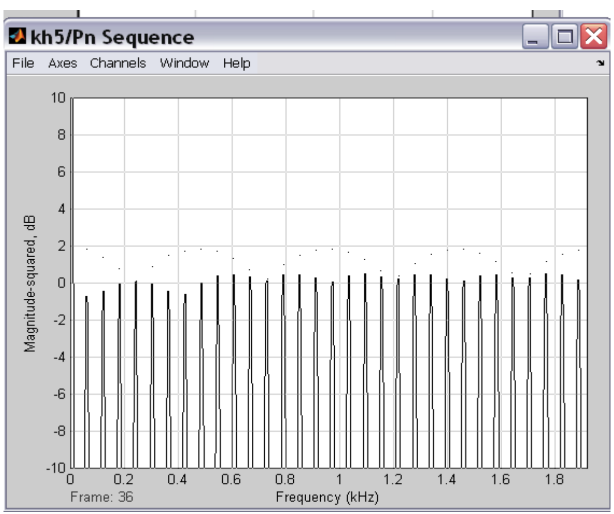

Figure 7. BFFT scope output of PN Sequence

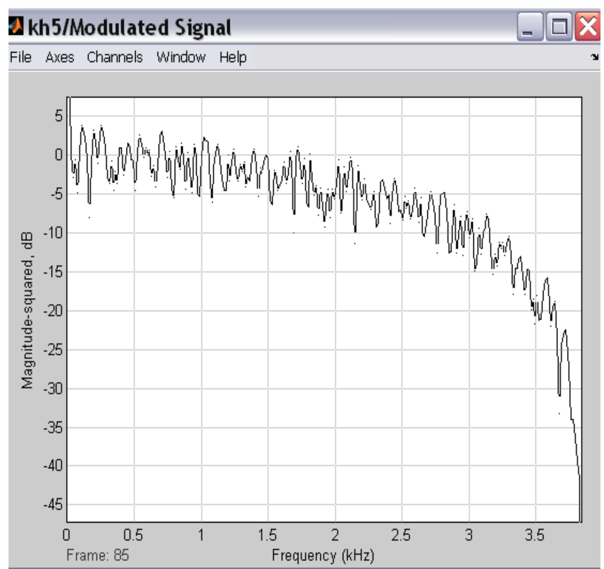

Figure 9.BFFT Scope output of Modulated Signal

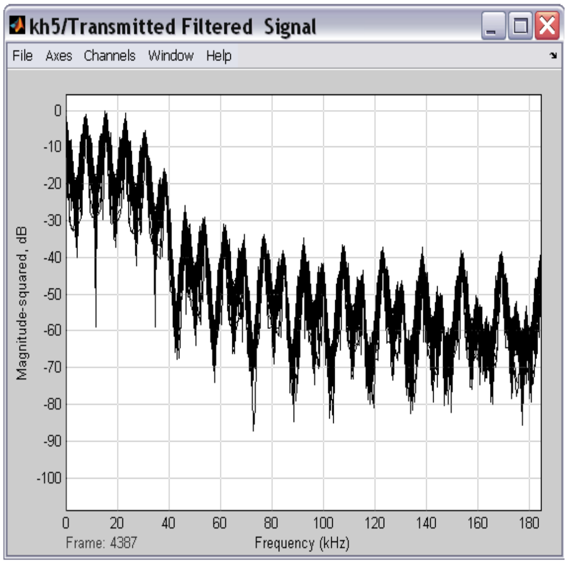

Figure 10. BFFT Scope Output of Transmitted Filtered Signal

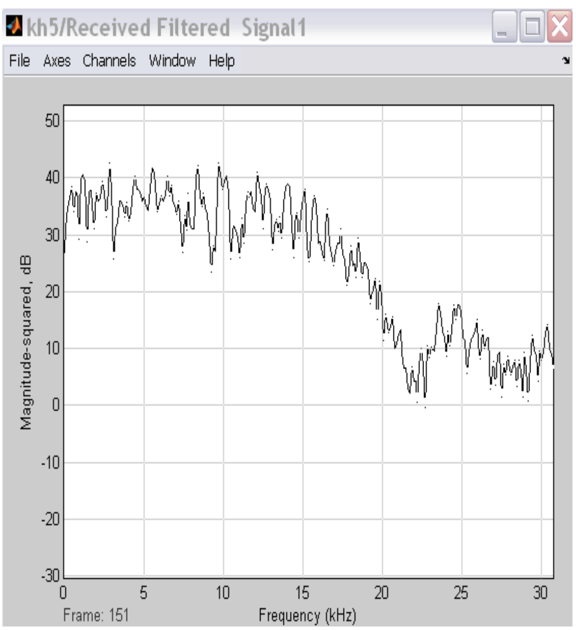

Figure 11.BFFT Scope of Received Filtered Signal

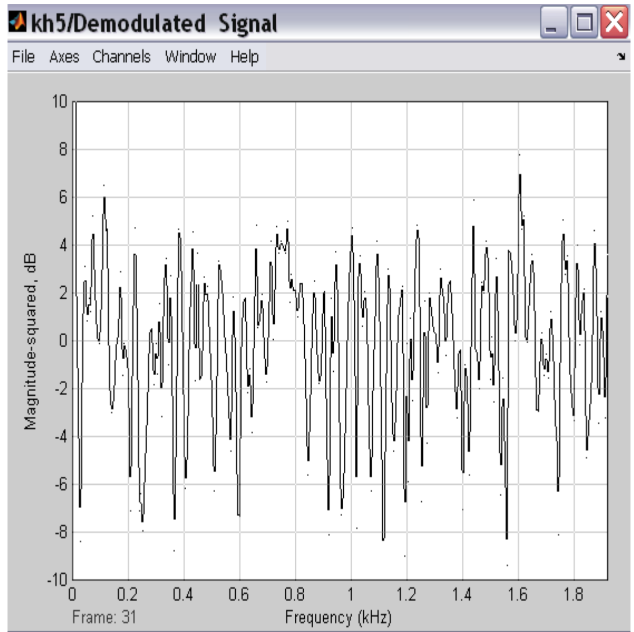

Figure 12.Discrete Time Eye Diagram Scope

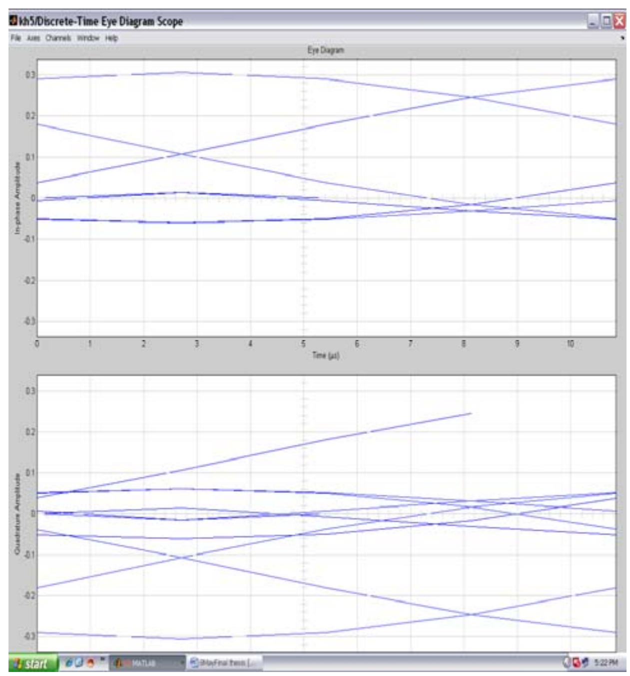

Figure13. BFFT scope of Demodulated Signal

6. Results and Discussion:

The simulation study has also been carried out for different values of D i.e.2,4,6 and 8. The simulation results for BER along with the number of errors and number of bits in each frame have been obtained. The readings of the simulation model for number of bits, number of errors and Bit Error Rate at different values of D have been taken at different time instants during the simulation runs. The parameters of the simulation model are given as below:

E_b/N_o=5dB, PN Sequence Generator Sample time=1/3840kbps,Bernoulli Binary Generator Sampletime=1/64kbps(data services) Interpolation FactorM=5,RollOffFactor =0.22(Optimum)[8]

The BER versus D Performance for WCDMA system is plotted in figure 14. It is observed that BER decreases as the group delay is increased from 2 to 4 and then from 4 to 6. The BER is found to increase as the value of group delay D is varied from 6 to 8 .Hence the group delay should be controlled at D=6 by RF design engineer .The values of D in the present study are in the range of digital pulse shaping filter as specified by Ken Gentile (2<D<20) [11].Hence the optimum value of D=6 is taken for subsequent analysis in WCDMA system.

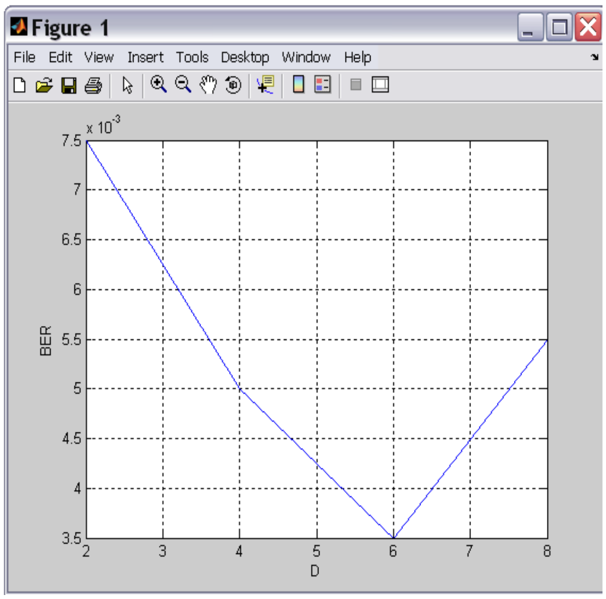

Figure 14. BER versus Group delay D for WCDMA at 5Mhz

The 3D Line Plot between Roll Off Factor Alpha, Interpolation factor M and Group Delay D is shown in figure 15 below. From the plot it is clear that at fixed value of roll off factor alpha(0.22) at D=6, M=5 .Hence other values of the parameters of pulse shaping filter can be determined from this graph.

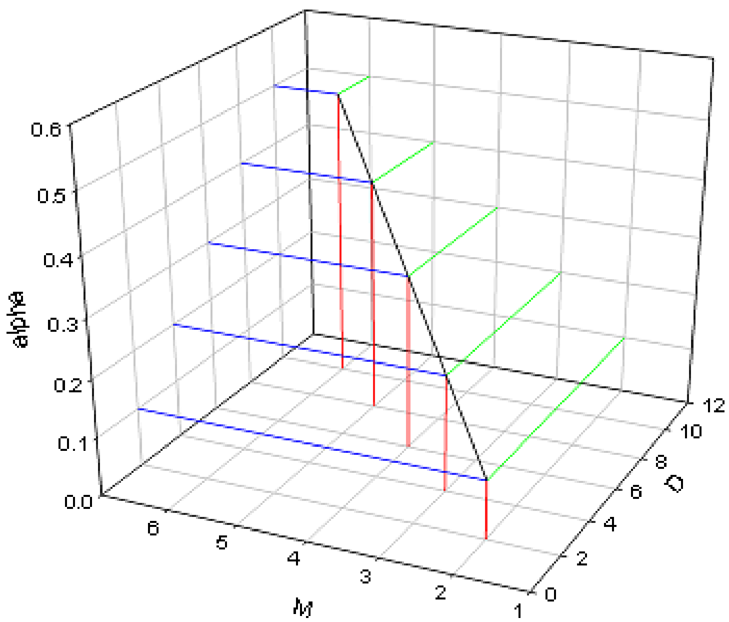

Figure 15: Three D Line Plot between Roll Off Factor Alpha,Interpolation factor M and Group Delay D

Effect of N,D on Performance Analysis of WCDMA based Simulation Model(through BER)

Figure 14 shows the effect of variation of Group Delay on the BER Performance of WCDMA at fixed value of alpha=0.22 and Interpolation factor M=5. The optimized value of D=6, is chosen for WCDMA based communication system using BER Simulation model. For minimizing the filter complexity, filter length or number of taps should be minimum as far as possible. The complexity of the filter increases as the value of D is increased. Increase in the values of BER,D and N is not at all acceptable for efficient performance of WCDMA based communication system. Our aim is to control the group delay .So we optimise the performance of our filter based model by taking value D=6 as optimum one that provides best possible results. Here at Roll Off Factor alpha=0.22 , D=6,M=5,Filter taps N=30;(N=D*M),Filterlength=1+N=31;BER=3.5*10^{-3}.

Conclusion

The present study has proposed the WCDMA communication link using OQPSK based system employing the pulse shaping filters using matlab simulink. The group delay plays a crucial role in pulse shaping digital finite impulse response filter.The value of group delay should be minimum for efficient performance of digital pulse shaping filter.The present study has highlighted the role of pulse shaping filter in WCDMA. A computer flowchart has been prepared and a program is written in Matlab 7.3 version .The time and frequency response of square root raised cosine pulse shaping filter at 5Mhz bandwidth has been studied .The effect of variation of group delay D i.e. number of symbols spanned by impulse response is studied at fix value of alpha=0.22 as well as at fix value of interpolation M=5.The study is useful in the reduction of complexity of filter.

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