Analysis of Simulation Parameters of Pulse Shaping FIR Filter for WCDMA

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Abstract

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 process and communications areas participate in this expanding field. 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. 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.The present paper deals with study of Simulation Parameters (Number of Bits, Number of Errors) of Pulse Shaping FIR Filter at different group delay for WCDMA.

Keywords: WCDMA, FIR Filter, Wireless Communication

1. Introduction

Digital Signal processing techniques are being used to improve the performance of 3G systems. WCDMA (Wideband Code-Division Multiple Access), an ITU standard derived from Code-Division Multiple Access (CDMA), is officially known as IMT-2000 direct spread spectrum.W-CDMA is a third-generation (3G) mobile wireless technology that promises much higher data speeds to mobile and portable wireless devices than commonly offered in today's market. W-CDMA can support mobile/portable voice, images, data, and video communications at up to 2 Mbps (local area access) or 384 Kbps (wide area access).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.

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:

$$Gp=Bt/Bi. \qquad \ldots\ldots\ldots\ldots\ldots(1)$$

Correlating the received signal with a code signal from a certain user will then only despread 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.

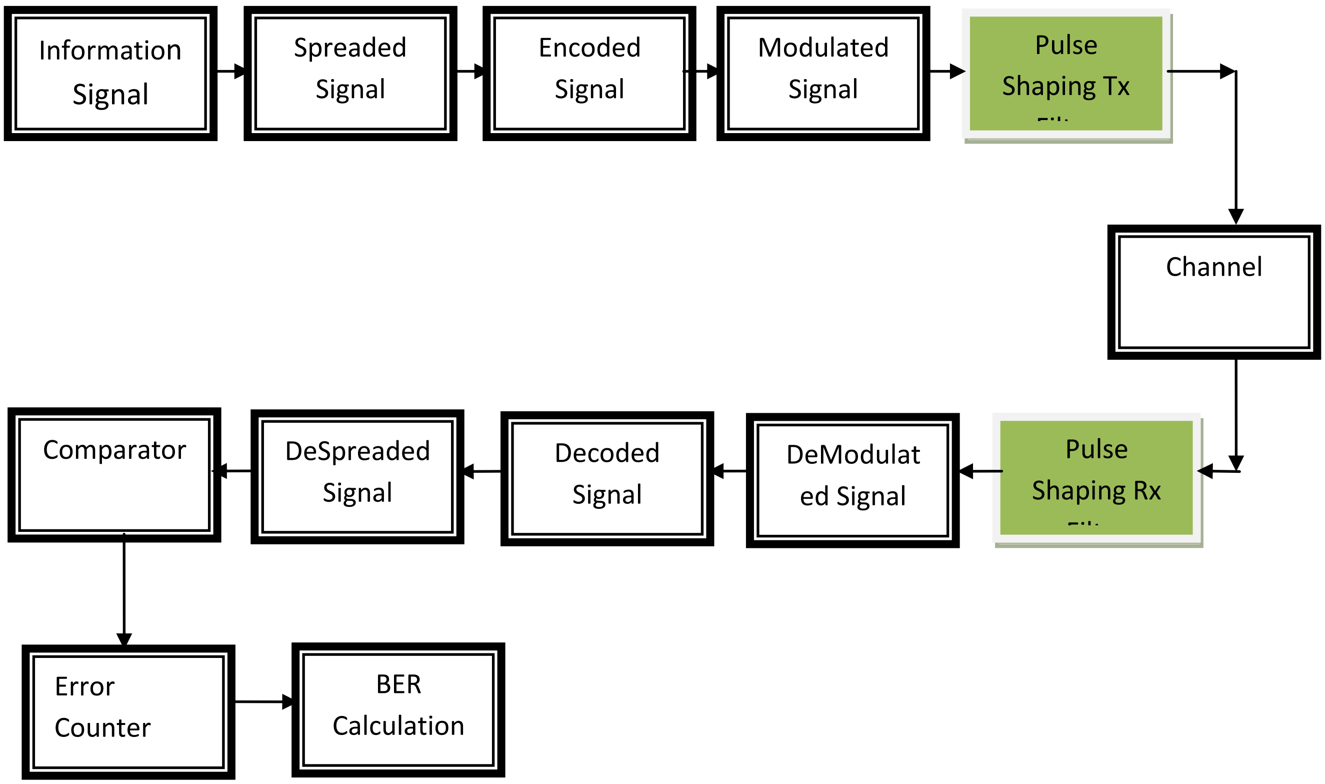

Fig. 1: Block diagram for WCDMA System

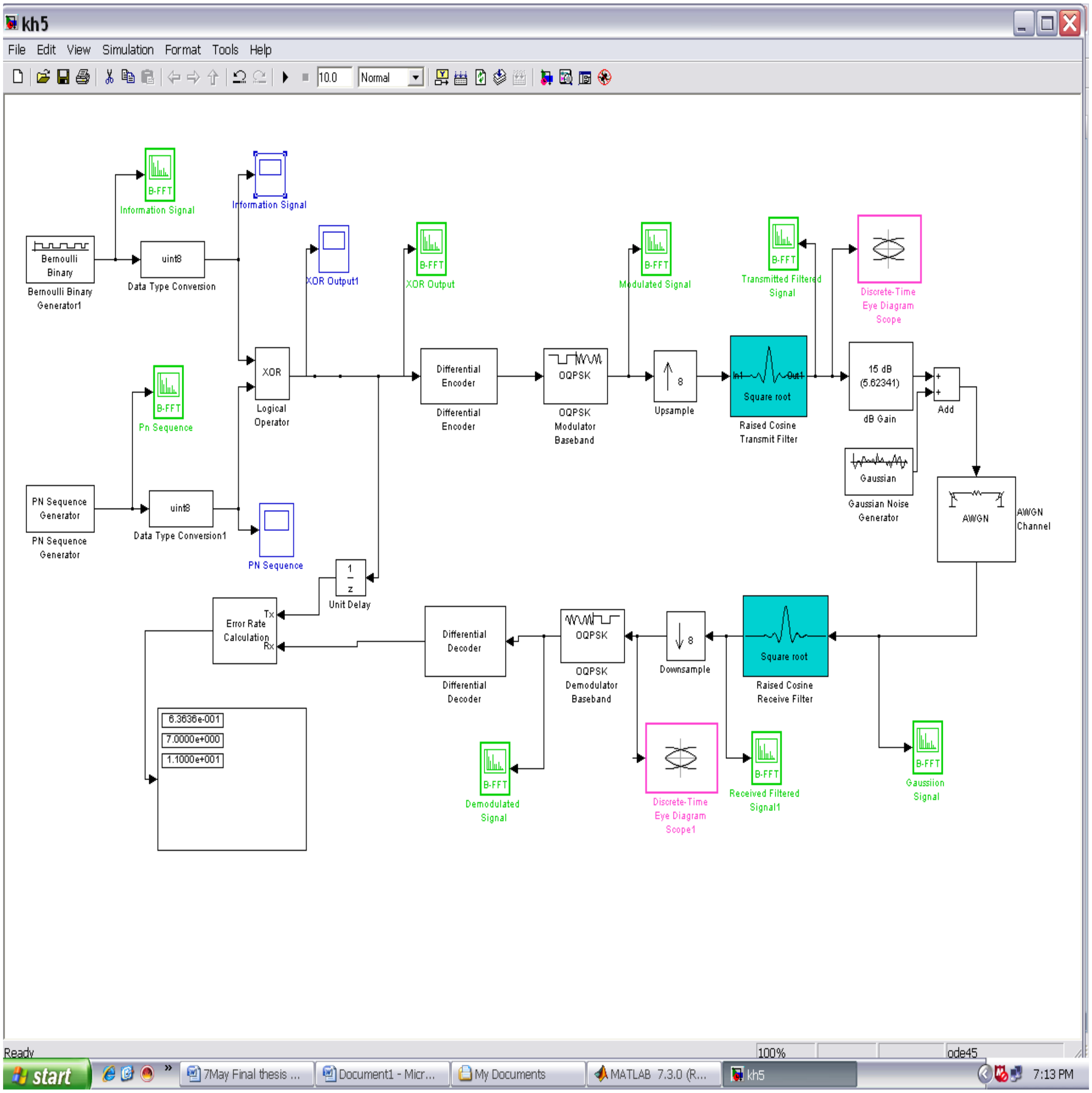

Fig. 2: WCDMA based Simulation Model developed for Square Root Raised Cosine Pulse

4.1 Description of Different Element Blocks used in making WCDMA Simulation Model:

(1) **Bernoulli Binary Generator**. Bernoulli Binary Generator is used to generate information signal appropriate with the standard for WCDMA from simulink library. Bernoulli Binary

Generator block as shown in figure generates random binary numbers using Bernoulli Distribution. The Bernoulli distribution has mean value 1-p and variance p(1-p).The probability of a zero parameter specifies p and can be any real number between zero and one. fig. 3 shows the block source parameters of Bernoulli Binary Generator.

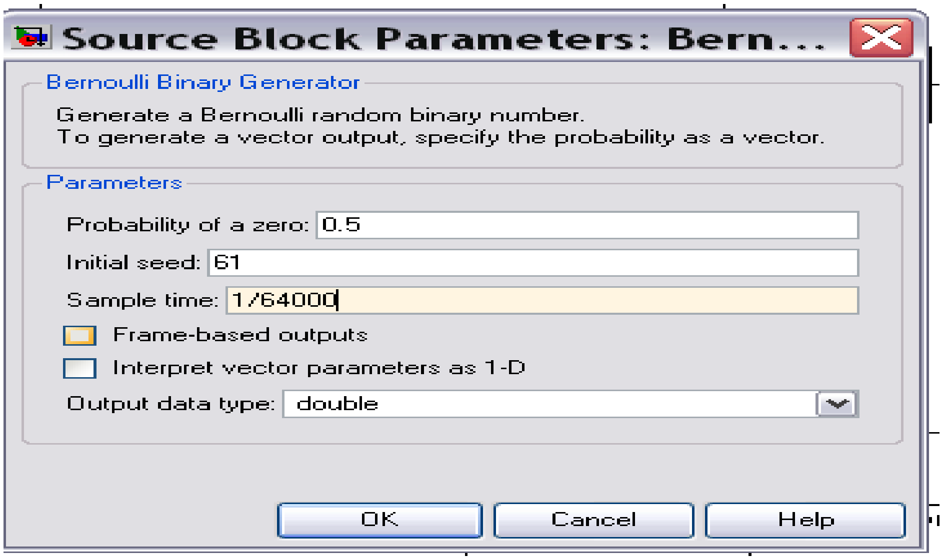

Fig. 3: Parameters of Bernoulli Binary generator

(2**) PN Sequence Generator**: The PN Sequence is produced by pseudo random noise generator that is simply a binary linear feedback shift register consisting of XOR gates and a shift register.This PN Sequence has the ability to create an identical sequence for both transmitter and receiver and yet retaining the desirable properties of a noise like randomness bit sequence. In Direct Sequence Spread Spectrum System,to generate a chip rate of 3.84Mbps for 5Mhz bandwidth in WCDMA system PN Sequence Generator has been used.PN Sequence generator block uses a shift register to generate sequences and all the parameters are shown in fig. 4 below.

(3) **XOR Logical Operator**: For single input operators are applied across input vector. For multiple inputs operators are applied across inputs.

(4) **Data Type Conversion Block**: It converts input to data type and scaling of output. This conversion has two possible goals. One goal is to have real world values of input and output be equal. Other goal is to have stored integer values of input and output be equal. Overflows and Quantization errors can prevent goal from being fully achieved.

(5) **Differential Encoder**: It differentially encodes the input data. The output of this block is a logical difference between present input to this block and previous output of this block. The input can be a scalar, vector or frame based matrix.

(6) **Modulator baseband**: It modulates the input signal using the offset quadrature phase shift keying method. The input can be either bits or integers. For sample based integer input, input must be a scalar. For frame based integer input, input must be a column vector. In case of sample based input, output sample time equals symbol period divided by 2. There are different variants such as QPSK, orthogonal QPSK (OQPSK).

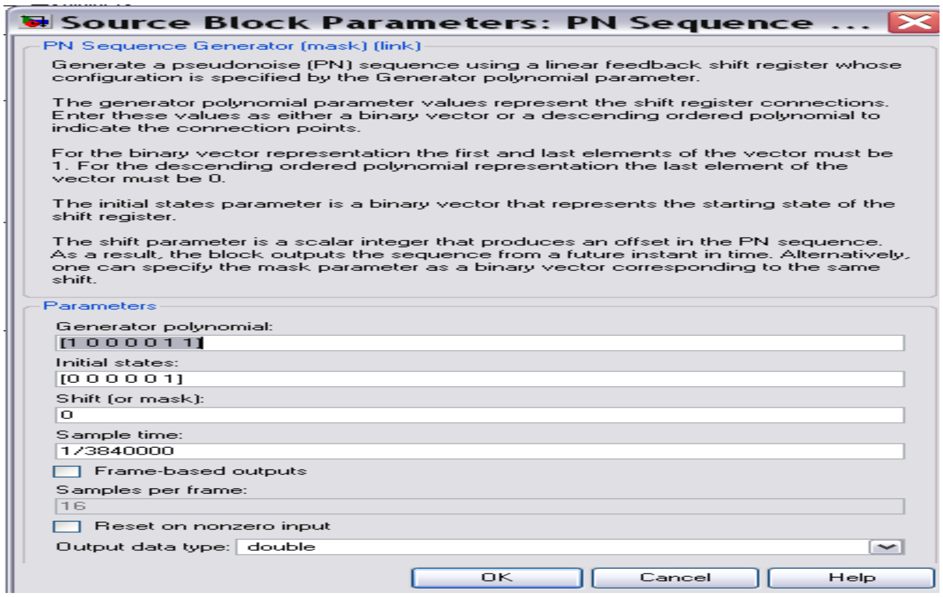

Fig 4 : Parameters of PN Sequence Generator

(7) **BFFT Scope**: This spectrum scope computes and displays the periodogram of each input signal. Non frame based inputs to this block should use buffering option.

(8) **Upsampling Block**: It upsamples the integer sampling rate by a factor of 8.

(9) **Square Root Raised Cosine Transmit Filter**: It upsamples and filters the input signal. The group delay is specified as the number of symbol periods between start of filter response and its peak. This delay also determines the length of filter impulse response which is 1+2*N*Group Delay. Various parameters of Square Root Raised Cosine Transmit Filter are shown in fig. 5 below.

(10) **Discrete Time Eye Diagram Scope**: It displays the multiple traces of modulated signal to reveal the modulation characteristics such as pulse shaping as well as channel distortions of signal.

(11) **dB Gain** :Here we apply the amplitude gain specified in dB. Here 5dB and 10 dB gain have been taken in present study for subsequent analysis.

(12) **Gaussian Noise generator**: It generates the Gaussian distributed noise with given mean and variance values.

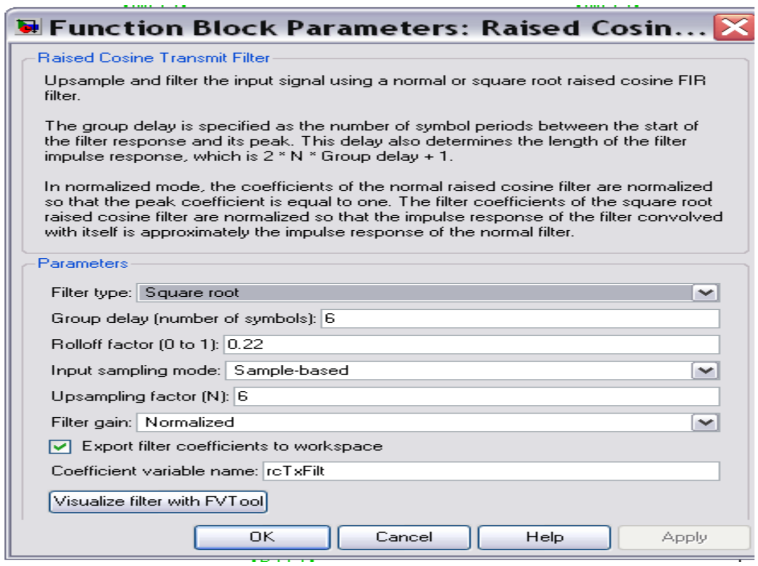

Fig 5: Parameters of Square Root Raised Cosine Transmit Filter

(13) **AWGN Channel**: It adds white Gaussian noise to the input signal.The input and output signals can be real or complex. This block supports multichannel input and output signals as well as frame based processing. Here in AWGN channel block,we can change E_b/N_o from 5dB to 10dB. Fig. 6 shows the function block parameters of AWGN channel.

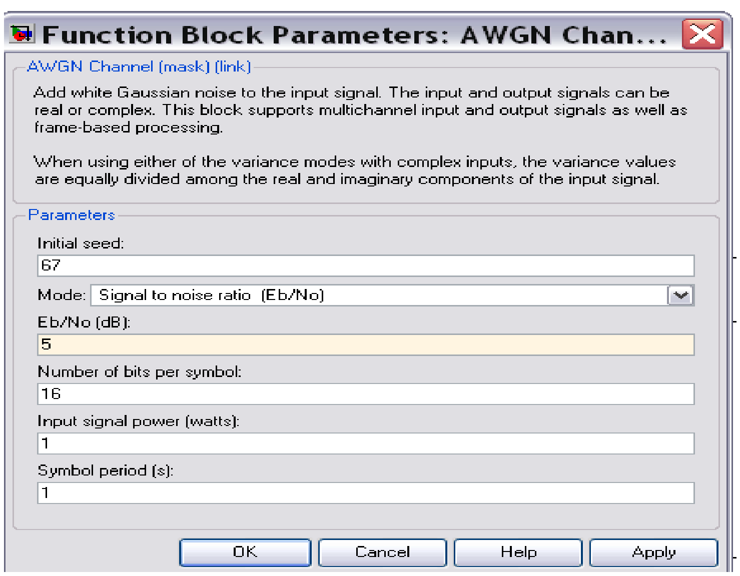

Fig 6: Parameters of AWGN Channel

(14) **Square Root Raised Cosine Receive Filter**: It filters the input signal and downsamples using Sq root raised cosine FIR filter. The group delay is specified as the number of symbol periods between start of filter response and its peak. This delay also determines the length of filter impulse response which is 1+2*N*Group Delay. Fig. 7 shows the different parameters of square root raised cosine receive filter.

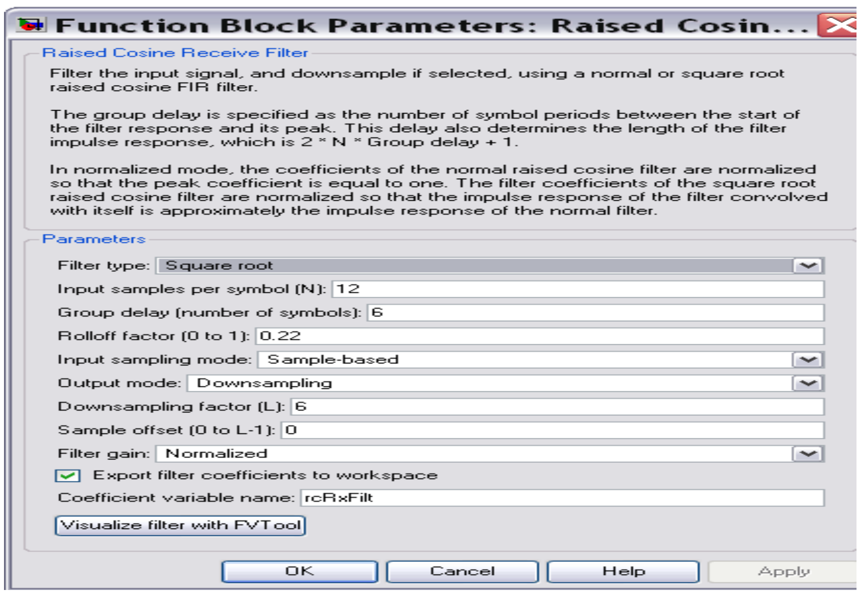

Fig 7: Parameters of Square root raised cosine Receive Filter

(15) **Downsampling Block**: It downsamples the input sample rate by integer factor .

(16) **Demodulator Baseband**: It demodulates the input signal using the offset quadrature phase shift keying method. The input can be either bits or integers. For sample based integer input, input must be a scalar. For frame based integer input, input must be a column vector. In case of sample based input, output sample time equals symbol period divided by 2. This block has variants such as QPSK, OQPSK.

17) **Differential Decoder**: It differentially decodes the input data. The output of this block is a logical difference between present input to this block and previous input of this block.The input can be a scalar, vector or frame based matrix.

(18) **Unit Delay**: It samples and hold with one sample period delay.

(19) **Error Rate Calculation Block:** It computes the error rate of received data by comparing it to the delayed version of transmitted data. The block output is a three element vector consisting of error rate followed by number of errors detected and total number of symbols compared.

(20) **Display:** It is for the numeric display of values input to it from error rate calculation block. Here one can get data display in different formats namely long_e,short,short_e,long,bank,hex (stored integer),binary(stored integer),decimal(stored integer),octal (stored integer).

The 'Stop Simulation' option stops the simulation upon detecting a target number of errors or a maximum number of symbols whichever comes first.

5. 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 and are summarized in tables 1, 2, 3,4.

Table 1: Results for Group Delay D=2

No of Bits	No of Errors	BER
1.0000e+000	0.0000e+000	0.0000e+000
2.0000e+000	1.0000e+000	5.0000e-001
3.0000e+000	1.0000e+000	6.3333e-001
4.0000e+000	2.0000e+000	7.5000e-001
5.0000e+000	3.0000e+000	6.0000e-001
6.0000e+000	4.0000e+000	6.6667e-001

Table 2: Results for Group Delay D=4

No of Bits	No of Errors	BER
1.0000e+000	0.0000e+000	0.0000e+000
2.0000e+000	1.0000e+000	5.0000e-001
3.0000e+000	2.0000e+000	6.6667e-001
4.0000e+000	3.0000e+000	5.0000e-001
5.0000e+000	3.0000e+000	6.0000e-001
6.0000e+000	4.0000e+000	6.6667e-001

Table 3: Results for Group Delay D=6

No of Bits	No of Errors	BER
1.0000e+000	0.0000e+000	0.0000e+000
2.0000e+000	1.0000e+000	2.0000e-001
3.0000e+000	1.0000e+000	3.3333e-001
4.0000e+000	2.0000e+000	3.5000e-001
5.0000e+000	3.0000e+000	6.0000e-001
6.0000e+000	4.0000e+000	6.6667e-001

Table 4: Results for Group Delay D=8

No of Bits	No of Errors	BER
1.0000e+000	1.0000e+000	1.0000e+000
2.0000e+000	2.0000e+000	1.0000e+000
3.0000e+000	2.0000e+000	3.6667e-000
4.0000e+000	3.0000e+000	5.5000e-000
5.0000e+000	4.0000e+000	8.0000e-001
6.0000e+000	4.0000e+000	6.6667e-001

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 Sample time=1/64kbps(data services) Interpolation Factor M=5,Roll Off Factor =0.22(Optimum)[8]. Fig.8 shows effect of change of group delay on number of errors in the simulation study.

It is also 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.

6. Conclusions

The present study has proposed the WCDMA communication link 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 minimal for efficient performance of digital pulse shaping filter. The effects of change in group delay on number of errors have been studied for square root raised cosine pulse shaping filter at 5 MHz bandwidth.

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[12-19]. The study has impact on analysis & simulation of pulse shaping families in WCDMA based wireless communication system [20-25].

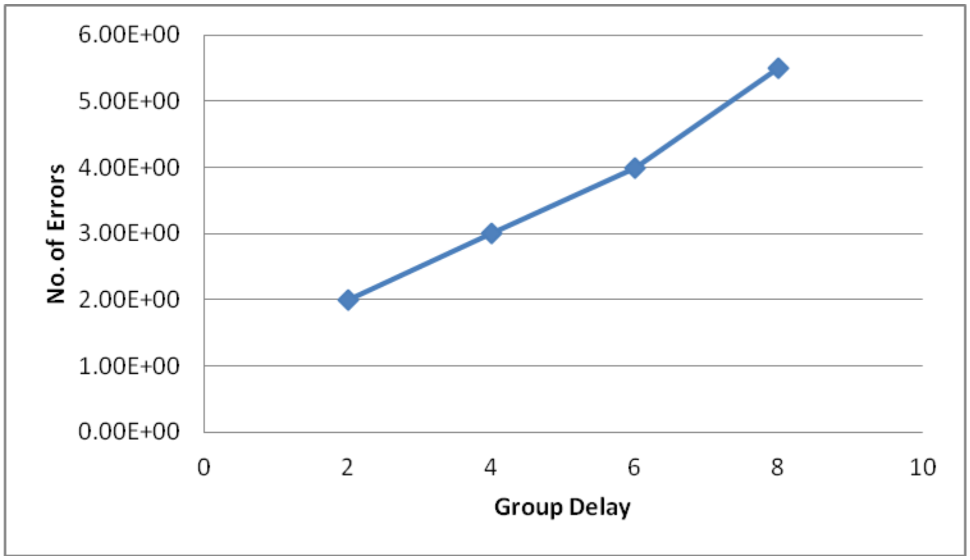

Fig 8: Number of Errors versus Group delay (D) for WCDMA at 5Mhz

The study will be useful to improve the performance of WCDMA based network by using the modified and improved design of square root raised cosine pulse shaping filter. Design of new type of filter of higher or different order will be useful to get better root raised cosine approximation thereby improving the performance parameters like increased Capacity, reduced BER, better S/N ratio, and Reduced ISI (noise) as a consequence of pulse shaping. The future work will involve the incorporation of interpolation factor for tradeoff between D and M at fix roll off factor as well as study of parameters of pulse shaping filter on the bit error rate performance analysis for WCDMA based wireless communication.

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