Comparative Performance Analysis of Different Pulse Shaping Filters for WCDMA System

Jitendra Kumar Shukla[1] B.S Rai[2]
[1] Student [2] Professor HOD
[1,2]Department of Electronics and communication Engineering
[1,2] MMM University of Technology Gorakhpur, U.P, India

Abstract--- The application of pulse shaping techniques to Wireless communication is an area that has achieved a great improvement in performance of wireless communication [1, 9]. Pulse shaping filters are used at the heart of many modern data transmission systems (e.g. mobile phones, HDTV) to keep a signal in the given bandwidth, maximize its data transmission rate, and to minimize transmission errors. Different pulse shaping filters form a well-established solution to this problem for wireless communication system. This paper deals with the comparative performance analysis of different pulse shaping filters for WCDMA system using AWGN channel. A simple WCDMA based communication link has been developed using SIMULINK tool of MATLAB R2013a and its performance in terms of BER is compared for different filters at same group delay (D).

Keywords: - Wireless communication, pulse shaping, RRC filter, AWGN, WCDMA

I. INTRODUCTION:

With the recent exploding research interest in wireless communication the application of signal processing to this area is becoming increasingly important. Indeed, it is advances in signal processing technology that make most of today's wireless communication possible and hold potential to provide better future services [9]. In a digital communication system, information can be sent on a carrier through changes in its fundamental characteristics such as: phase, frequency, and amplitude. As the characteristics of carrier signal changes sharp transitions comes into picture which require much high frequency component in frequency domain. In a realizable channel, these transitions can be smoothed, based on the filter's implemented in transmission and the requirements of large bandwidth is also reduced. In fact, the use of a filter plays an important part in a communications channel because it is effective at eliminating interference from adjacent symbols (Inter Symbol Interference, ISI), reducing channel width, and eliminating spectral leakage. To satisfy the ever increasing demands for higher data rates as well as to allow more users to simultaneously access the network, WCDMA technology are used in present days. 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 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 and data rates of 144 and 384 Kbps is used to lead a carrier bandwidth of 5Mhz.WCDMA also supports high user data rates (up to 2 Mbps) and increased multipath diversity[13,14]. 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.

II. REQUIREMENTS OF PULSE SHAPING

There are two conflicting requirements in wireless communication are the demand for high data rates per channel (or user) and requirement for more channels. Theoretically as the channel bandwidth is increased to provide higher data rates the number of channels allocated in a fixed spectrum must be reduced. Tackling these conflicting requirements at the same time led to the development of the pulse shaping filters. More channels with wider bandwidth might be tightly packed in the frequency spectrum achieving the desired goals. Wireless communications channel demand the use of a pulse shaping filter for -

a) Generating band limited channels, and
b) Reducing Inter Symbol Interference (ISI) arising from multi-path signal reflections [1].

Examples of pulse shaping filters which are commonly found in communication systems are:

– Raised Cosine filter
– Square root raised cosine filter
– Gaussian Pulse shaping filter

III. DESCRIPTION OF DIFFERENT PULSE SHAPING FILTERS:

A. *Raised Cosine (RC) Filter:*

The raised cosines filters are frequently used for pulse shaping in digital modulation due to its ability to minimise inter symbol interference. Its name stems from the fact that

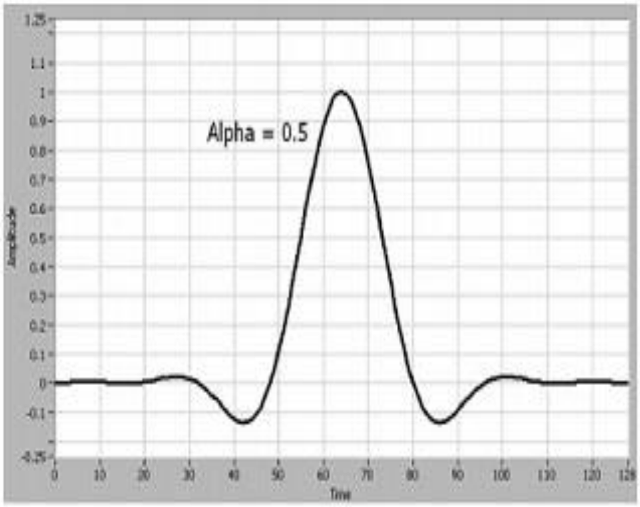

Fig. 1: Impulse response of raised cosine filter.

The non-zero portion of frequency spectrum of its simplest form is a cosine function 'raised' up to sit above f axis.

Mathematically the impulse response of raised cosine filter in terms of normalized sinc function is given as

$$h_{RC}(n) = \frac{\pi}{4}\operatorname{sinc}\left(\frac{\pi n}{R}\right) \cdot \left[\operatorname{sinc}\left(\frac{\pi}{2} - \alpha\frac{\pi n}{R}\right) + \frac{\sin\left(\frac{\pi}{2} - \alpha\frac{\pi n}{R}\right)}{\left(\frac{\pi}{2} + \alpha\frac{\pi n}{R}\right)}\right]$$

Where α is roll-off factor and R is the number of samples per symbol.

This filter is used in many communication system due to its property of eliminating ISI as its impulse response is zero at all nT except n = 0

B. Square Root Raised Cosine (SRRC) Filter:

The square root raised cosine filter produces a frequency response with unity gain at low frequencies and complete at high frequencies. It is commonly used in communication system in pairs where the transmitter first applies a root raised cosine filter and then the receiver applies matched filter. Mathematically root raised cosine filter is defined as follows-

$$h_{SRC}(t) = \frac{\left[\frac{4\alpha}{\pi}\cos\left(\frac{(1+\alpha)\pi n}{R}\right)\right] + \left[(1-\alpha)\operatorname{sinc}\left(\frac{(1-\alpha)\pi n}{R}\right)\right]}{\sqrt{R}\left[1-\left(\frac{4\alpha n}{R}\right)^2\right]}$$

α is roll-off factor which determines the sharpness of frequency response. R is the number of samples per symbol. The sinc pulse is used to shape the so that it appears with a finite frequency response. The impulse response of root raised cosine filter is given as-

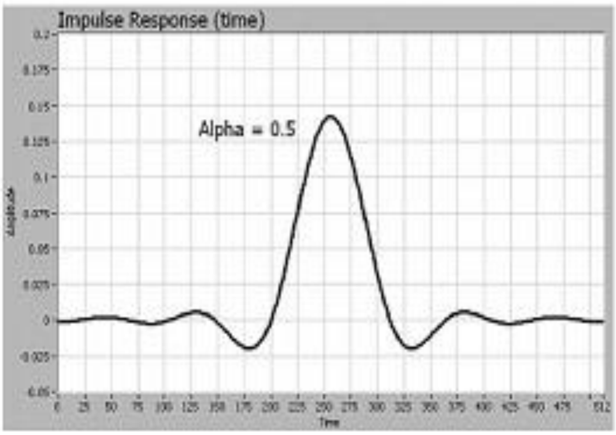

Fig. 2: Impulse response of square root raised cosine filter

C. Gaussian filter:

Gaussian filter is a pulse shaping technique that is typically used for frequency shift keying (FSK), and minimum shift keying (MSK), modulation. This filter is unlike the raised cosine filter and root raised cosine filters because it does not implement zero crossing points. Impulse response for Gaussian filter is defined by the following mathematical equation-

$$h_G(t) = Q\left(\frac{2\pi\alpha}{\sqrt{\ln 2}}\left(n-\frac{1}{2}\right)\right) - Q\left(\frac{2\pi\alpha}{\sqrt{\ln 2}}\left(n+\frac{1}{2}\right)\right)$$

And following figure shows the impulse response of Gaussian filter-

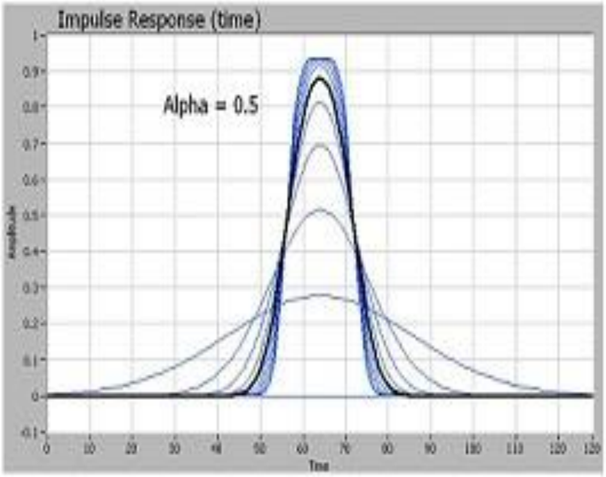

Fig. 3: Impulse response of Gaussian filter

IV. PROPOSED SIMULATION MODEL:

Following simulation model has been proposed for analysing the effect of various pulse shaping filters on BER for WCDMA based communication system. The proposed model uses the offset Quadrature phase shift keying (OQPSK) modulation technique and different pulse shaping filter such as raised cosine, root raised cosine and Gaussian for pulse shaping with WCDMA arrangement for wide area access networks i.e. at 384 kbps. The simulation model has been developed using SIMULINK tool of MATLAB by using different blocks from simulink library. Important blocks are – Bernoulli generator, PN sequence generator, differential encoder and decoder, AWGN channel, error rate calculation block, display. BER for different filters are compared with one another to determine which filter give best performance in terms of BER.

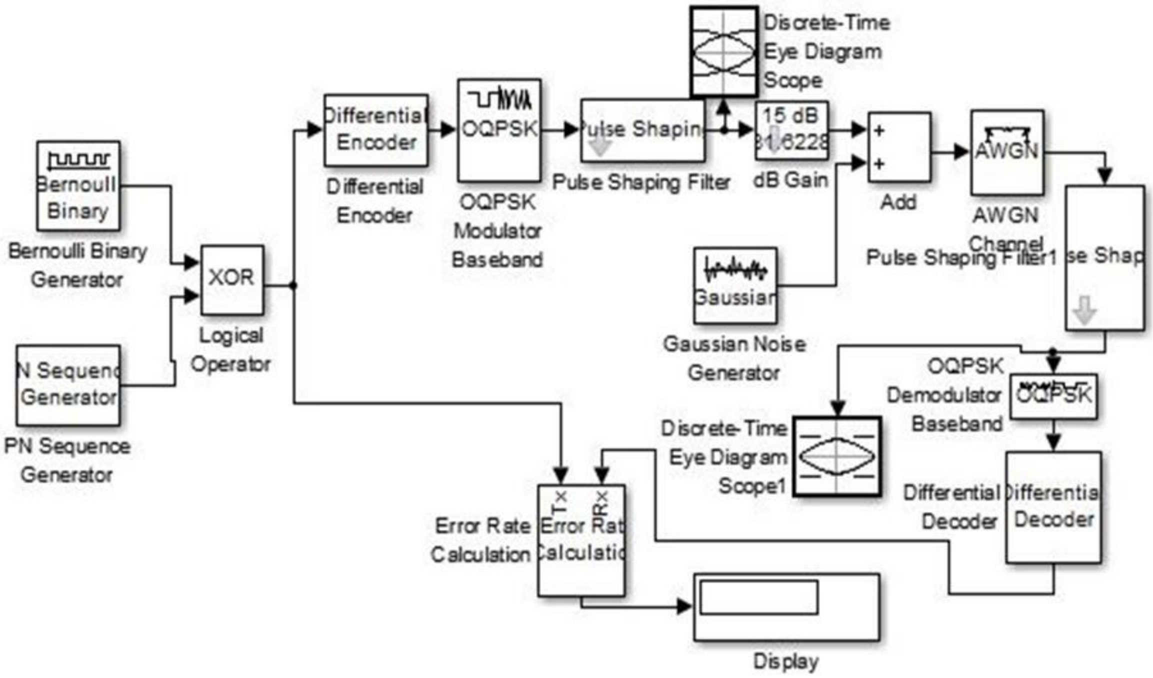

Fig. 4: simulation model for WCDMA communication system using different pulse shaping filters

V. SIMULATION RESULT

The simulation study has been done for different pulse shaping filters at different Group delay (D). The simulation has been carried out at 384 kbps, roll-off factor (α) = 0.22, input samples per symbol (N) = 8, samples per frame= 4, up-sampling and down-sampling factor= 8, simulation run time= 10 seconds.

Table. 1: Ber response of filters w.r.t. Group Delay (D)-

Group Delay (D)	RC Filter	SRRC Filter	Gaussian Filter
2	0.4976	0.4952	0.4904
4	0.4968	0.4900	0.5048
5	0.4920	0.4772	0.4968
6	0.4924	0.4836	0.4968
8	0.4792	0.5088	0.4968

The above table shows BER performance of different pulse shaping filters and it indicates that optimum bit error rate is obtained in the case of Square root raised cosine filter.

Following plots shows the variation of BER versus Group delay for different pulse shaping filter-

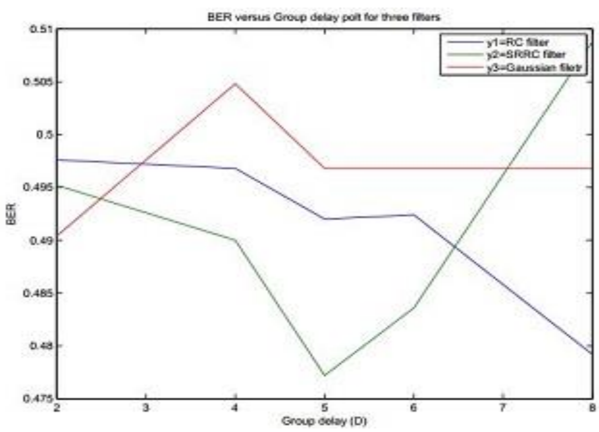

Fig. 5:

VI. CONCLUSION

We have analysed different pulse shaping filters for above WCDMA communication simulation model and found that the performance of Square root raised cosine filter is best among the three pulse shaping filters for wide area access network i.e. at 384 kbps and the minimum BER for all the filter is obtained at group delay (D)= 5 in case of Square root raised cosine filter i.e. BER = 0.4772.

REFERENCES

[1] N J Bass and DP Taylor, " Pulse Shaping for wireless communication over time/frequency selective channel", IEEE Transactions on communication, vol. 52, no9 Sept 2004, pp1477-79, (2004).
[2] Pal Orten, "Some Results on Pulse Shaping in DS-CDMA Systems", AC090/CTH /A11/PI/I/004, pp no 1-6 (2004).
[3] A S Kang and Vishal Sharma, "Analysis of Parameters of Square Root Raised Cosine Pulse Shaping Digital FIR filter for WCDMA at 5Mhz" International Journal of Electronics Engineering Research Vol2 (2), pp 253-260. (2010)
[4] A S Kang and Vishal Sharma, "Simulation of pulse shaping FIR filter for WCDMA" IUP Journal of Information Technology(2010).
[5] A S Kang and Vishal Sharma, "Simulation Study of FIR Filter for Complexity Analysis in WCDMA" International Journal of Engineering Science and Technology Vol2 (4), pp 683-692. (2010)
[6] Rapport, T.S, wireless communication: Principles and Practice, 2nd edition, Prentice-Hall
[7] Bernard Sklar," Digital communication: Fundamentals and applications", Prentice-Hall, 2nd edition

