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## **Comparative Analysis of Flipped Exponential Pulse with Square Root Raised Cosine for WCDMA Using Digital Filtering Approach**

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### **ABSTRACT**

Signal Processing Techniques are being employed in the field of wireless communication to enhance the performance of the system. Service providers are deploying third generation (3G) wireless base stations that enable the user to surf the web, check e-mail, conduct video conferences and access a wide range of new services from their wireless devices. Underlying 3G innovations, Wideband Code Division Multiple Access (WCDMA) technology is pushing the expectations of wireless networks far beyond the previous limitations of 1G and 2G. To deliver on the promise of 3G, WCDMA system must handle the greater capacity, higher data rates and support multimedia standards while at the same time reduces the size, cost and the power consumption. The large expectations through WCDMA are based on its flexibility for multimedia capabilities and the high capacity. However, the demanded traffic grows rapidly and new capacity enhancements are required in order to satisfy the future needs. The present paper deals with Performance comparison of flipped exponential pulse (s2) with square root raised cosine (s1) for WCDMA. The aim of the present study is to select an appropriate pulse shaping family for simulation of WCDMA model at 5 MHz the digital filtering approach have been applied for comparative analysis of two different pulse shaping families. It has been found that main lobe attenuation is 1.5 in s1 family while 0.75 in s2 family aliasing is more in s2 family as compared to s1. S1 family is found to be better than s2 for the purpose of simulation of WCDMA based model at 5 MHz.

**Key words:** Third generation, multiple access techniques, digital filtering, square root raised cosine, flipped exponential pulse

### **INTRODUCTION**

Wideband Code Division Multiple Access (WCDMA) technology has emerged as the most widely adopted 3G air interface. Its specification has been created in the 3rd Generation Partnership Project (3GPP) which is the joint standardization project of the standardization bodies from Europe, Japan, Korea, the USA and China (Holma and Toskala, 2002).

Third Generation systems started with the vision to develop a single global standard which fulfilled all the demands of a user with high speed data and high quality voice services. In the International Telecommunication Union (ITU), third generation networks are called IMT-2000. The

leading standards of different countries create a new group called the Third-Generation Partnership Project (3GPP) (Ojanpera and Prasad, 2001), [www.3gpp.org](http://www.3gpp.org). This group became the driving force behind the development of 3G standards. Emerging requirements for higher data rate services and better spectrum efficiency are the main driver's identities for the third generation mobile radio systems. There are many leading 3G systems in current scenario such as WCDMA, CDMA 2000 and Multicarrier CDMA but the present study deals with WCDMA (Kirby, 1999; Prasad and Ojanpera, 1998; Dahlman *et al.*, 1998).

Wideband Code Division Multiple Access (WCDMA) has been chosen as the basic radio access technology for UMTS/IMT-2000 in both Europe and Japan (Kirby, 1999). WCDMA is a step further in the CDMA technology. It uses a 5 MHz wide radio signal and a chip rate of 3.84 Mcps as shown in Fig. 1, which is about three times higher than the chip rate of CDMA2000 (1.22 Mcps) (Prasad and Ojanpera, 1998; Dahlman *et al.*, 1998). The main benefits of a wideband carrier with a higher chip rate are:

- **High mobility:** The 144 Kbps for outdoor rural users who are travelling at speeds greater than  $120 \text{ km h}^{-1}$
- **Full mobility:** The 384 Kbps for users travelling less than  $120 \text{ km h}^{-1}$  in urban areas
- **Limited mobility:** The 2 Mbps for users who are moving at less than  $10 \text{ km h}^{-1}$

Quality of Services (QoS) is supported from end to end in 3G systems, unlike 2.5 G predecessors.

The goal of next generation mobile communication system is to provide seamlessly wide variety of communication services to anybody, at anytime and anywhere. The intended services for next generation mobile phone users include transmitting high speed data, video and multimedia traffic and voice signals. The technology needed to tackle the challenges to make the service available is popularly known as third generation (3G) cellular systems (Holma and Toskala, 2002; Ojanpera and Prasad, 2001; Prasad and Ojanpera, 1998; Dahlman *et al.*, 1998). The large expectations through WCDMA are based on its flexibility for multimedia capabilities and the high capacity. However, the demanded traffic grows rapidly and new capacity enhancements are required in order to satisfy the future needs. The analysis and simulation of transmit and receive pulse shaping filter is an important aspect of digital wireless communication since it has a direct effect on error probabilities. Pulse shaping for wireless communication over time as well as frequency selective channels is the need of hour for 3G and 4G systems. The pulse shaping filter

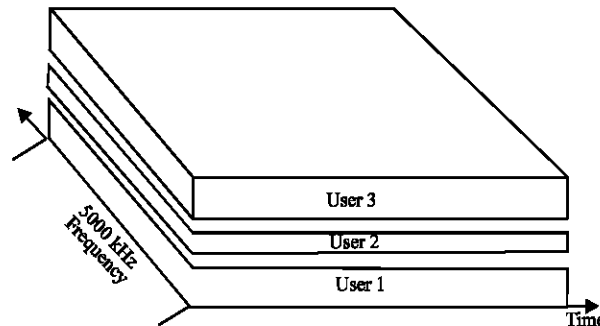


Fig. 1: Bandwidth in WCDMA in the time-frequency code space (Kirby, 1999)

is a useful means to shape the signal spectrum and avoid interferences. The aim of the present study is selection of suitable pulse shaping family for simulation of WCDMA at 5 MHz.

**PULSE SHAPING IN WIRELESS TECHNOLOGIES USING DIGITAL FIR FILTER FOR WCDMA**

The Linear Time Invariant (LTI) model of a FIR pulse shaping filter is presented in Fig. 2. It is described by the following difference Eq:

$$y[n] = \sum h[k] * x[n-k] \tag{1}$$

where,  $x[n]$  is current input sample,  $x[n-k]$  are discrete input samples delayed by  $k$  sample periods  $h[k]$  are filter coefficients or taps and  $y[n]$  is the current discrete output sample of the filter.

**Square root raised cosine pulse:** The impulse response of pulse shaping FIR filter for Square Root Raised Cosine Pulse is given by:

$$RC_c(t) = \text{Sin}(\pi/T_c(1-\alpha) + 4\alpha(t/T_c)) \cos(\pi/T_c(1+\alpha)/( \pi/T_c(1-4\alpha t/T_c)^2) \tag{2}$$

where, the roll off factor  $\alpha = 0.22$  and  $T_c$  is the chip duration (Assalini and Tonello, 2004; Gentile, 2002).

**Flipped exponential pulse:** It is known as flipped-exponential pulse. In this pulse a new parameter,  $\beta = \ln 2/\alpha$  has been introduced (Assalini and Tonello, 2004). The frequency and impulse responses of this family are given as below:

- $S2(f) = 1 \dots \dots \dots f \leq B(1-\alpha)$
- $S2(f) = \text{Exp}(\beta(B(1-\alpha)-f)) \dots \dots \dots B(1-\alpha) < f \leq B$
- $S2(f) = 1 - \text{exp}(\beta(f-B(1+\alpha))) \dots \dots \dots B < f \leq B(1+\alpha)$
- $S2(f) = 0 \dots \dots \dots B(1+\alpha) < f$
- $S2(t) = (1/T) \text{sinc}(t/T) (4\beta\pi t \sin(\pi\alpha t/T) + 2\beta^2 \cos(\pi\alpha t/T) - \beta^2) / [(2\pi t)^2 + \beta^2]$

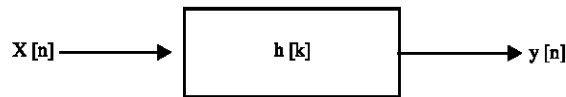


Fig. 2: FIR filter model

Table 1: Filter specifications

Specification	Values
Symbol rate	3.84 msymbols/sec
Cut-off frequency $F_c$	Symbol Rate/2
Sampling frequency $F_s$	Interpolation factor*Symbol Rate

The specifications used to calculate the impulse response of the filter are presented in the Table 1 as shown below (Dahlman *et al.*, 1998; Vejanovski *et al.*, 2001). The sampling frequency and filter complexity depend upon the interpolation factor.

**METHODS**

The following software as shown below in Fig. 3 has been used in the present study.

**MATLAB 7.3:** Developed by Math works Inc. stands for Matrix Laboratory. It is a software package used to perform scientific computations and visualization. Its capability for analysis of various scientific problems, flexibility and powerful graphics makes it a very useful software package. It provides an integrated development environment for programming with numerous predefined functions for technical computations and visualization. Besides available built in functions, user defined functions can also be included, which can be just like any other built in function. The flowcharts have been prepared and computer programs have been written in matlab 7.3 version to compute the parameters for analysis square root raised cosine digital pulse shaping filter [S1] as well as Flipped Exponential [S2]. As per recommendations of ITU-3G partnership project, Square Root Raised Cosine filter has been recommended for WCDMA (Dahlman *et al.*, 1998). These two pulse shaping families have been analyzed and compared using parameters of WCDMA at 5 MHZ (with input signal data rate of 3.84 Mcps).

The comparison between two families is shown in Table 2.

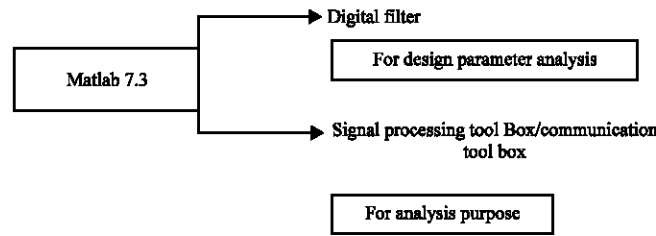


Fig. 3: Software tool used in present study

Table 2: Frequency domain comparative analysis of S1, S2 families

S1 (RCOS)	S2 (FEXP)
Impulse response	Impulse Response
$S1(t) = \text{sinc}(t/T) \cos(\pi \alpha t/T) / (1 - (2\alpha t/T)^2)$	$S2(t) = 1/T \text{sinc}(t/T) 4\beta \pi t \sin(\pi \alpha t/T) + 2\beta^2 \cos(\pi \alpha t/T) - \beta^2 / 4 \pi^2 t^2 + \beta^2$
It is raised cosine family	It is called Beaulieu family
Robustness to Root and Truncation Operations: No	Yes
Asymptotic Decay: $s1(t)$ decays as $1/t^3$	It decays as $1/t^2$
Amplitude of main side lobe for this pulse with $1/t^3$ decay is larger than those with $1/t^2$ decay	Here amplitude of main side lobe is smaller than those with $1/t^3$ decay
Performance Analysis : For diff ROFs and Sampling time errors, $t^{-3}$ pulse is beaten by S2.	Here good performance is there due to $t^{-2}$ decay.
Complexity: More	Less
ISI: Less ISI due to $1/t^3$ decay	Here is more ISI due to $1/t^2$ decay
Noise Margin: Smaller	These pulses exhibit larger noise margin for sampling offsets larger than $0.05T$
Eye Opening:	It has large Eye opening
BER:	It shows good BER Results

## **RESULTS AND DISCUSSION**

The effects of variation of roll off factor, Group delay and interpolation factor for these two pulse shaping families for digital FIR filter for WCDMA have been studied by Kang and Sharma (2008a, 2009a, 2010a). Finally a comparison has been drawn among two pulse shaping families to conclude that which one suits the best to WCDMA at 5 MHz bandwidth with input sampling rate = 3.84 Mbps ~3840 Kbps. The value of roll of factor should be optimum by Kang and Sharma (2008b).

In case of Square root raised cosine pulse (S1 family), amplitude of main lobe is 1.5 and the amplitude in pass band of flipped exponential pulse (S2) is (0.75) less as compared to that in case of S1. Also, pass band is found to increase in case of S2 (F<sub>exp</sub>) as compared to S1 (Sq root raised cosine) by Kang and Sharma (2009b). The results for the responses of flipped exponential family for different values of roll off factor show that for  $\alpha = 1$ , its response is even worse as compared to raised cosine family. It has greater tendency of aliasing as response dies out at slower rate than the previous square root Raised Cosine family for the WCDMA bandwidth of 5 MHz.

Hence S2 family is not suitable for WCDMA as compare to S1 on the basis of slower side lobe tail decay by Kang and Sharma (2010b, 2011). 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. Signal processing plays a crucial role in wireless communication for variety of applications (Holma and Toskala, 2002; Ojanpera and Prasad, 2001, [www.3gpp.org](http://www.3gpp.org)). Data communication using pulse shaping techniques has a critical role in a communication system (Kirby, 1999; Prasad and Ojanpera, 1998). In digital telecommunication, pulse shaping is the process of changing the waveform of transmitted pulses. Its purpose is to make the transmitted signal suit better to the communication channel by limiting the effective bandwidth of the transmission. In Radio Frequency Communication, pulse shaping is essential for making the signal fit in its frequency band (Dahlman *et al.*, 1998; Assalini and Tonello, 2004; Gentile, 2002). The analysis and simulation of transmit and receive pulse shaping filter is an important aspect of digital wireless communication since it has a direct effect on error probabilities. Pulse shaping for wireless communication over time as well as frequency selective channels is the need of hour for 3G and 4G systems.

## **CONCLUSION**

The present study has highlighted the Performance comparison of flipped exponential pulse (s2) with square root raised cosine (s1) for WCDMA using digital filtering approach. The S1 family is found to be superior as comparison to S2 family on the basis of slower side lobe tail decay. The study provides the basis for study of s1 family for WCDMA simulation at 5 MHz.

### **Impact of study:**

- The study is useful to improve the performance of WCDMA Network
- In the planning of WCDMA Network
- To achieve the flexibility in use of data rates in different environments
- Design of future cellular mobile communication network

In future, DSP algorithms can be developed for performance enhancement of WCDMA based wireless system using optimized values of parameters of pulse shaping filters and Simulation study can be done to different data rates such as 144 kbps, 384 kbps and 2 Mbps.

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