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Performance Analysis of Near Perfect Reconstruction Filter Bank in Cognitive Radio Environment

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ABSTRACT

The present paper puts its focus on the design of an efficient prototype Filter bank in the context of Filter Bank based Multicarrier Transmission. A benefit of the chosen technique is that,a near perfect reconstruction polyphase filter can be designed with the aid of closed form expressions with a slight adjustment in parameters of interest. The entire performance of the filters designed is analyzed and evaluated using Offset-OQAM for FBMC system. Optimization or performance tradeoff is readily obtained by appropriately adjusting those free parameters. Whatsoever results are obtainable are presented for useful analysis to the rf design engineers working in the domain of multi rate signal processing for wireless communication. An attempt on NPR Filter bank has also been made and to ensure the acceptable performance of Modified and Enhanced FBMC, computational complexity, system delay and transmission burst length need to be minimized/reduced. A single prototype filter designed may not provide the best performance in terms of all the metrics. The effect of Stop band attenuation on the edges of Magnitude and Frequency responses has been carefully studied. Different L_p, K and M factors have been considered during simulations and the results have been compared analytically.

Keywords: **Near Perfect Reconstruction, Filter Bank, Cognitive radio, Prototype filter**.

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I.INTRODUCTION

Higher Spectral Resolution, Decreased out of band emission and increased bit rate due to reduced guard bands and absence of cyclic prefix enables FBMC to allocate various subcarriers to differently available non-synchronized users in a dynamic and spectrally efficient way[1].FBMC multicarrier scheme uses a prototype filter with much better time-frequency product. FBMC signal localization in both time and frequency domain increases its robustness to timing error and frequency offset.A fast and parallel algorithm with unified structure approach for FBMC Transceiver have been proposed[1].The unique feature of FBMC technique is its capability to provide improved frequency selectivity through the use of longer and spectrally efficient prototype filter. Generally, FBMC makes use of Transmultiplexer (TMUX) design which basically consists of Analysis Filter Bank(with Downsampling) and Synthesis Filter Bank(with Upsampling provision).The increase and decrease in the sampling rate of a signal is associated with complex to real and real to complex conversion of input signal and that too with pre and post OQAM sub channel processing with some appropriate modulation technique applied therein. Thorough analytical study related to the FBMC subchannel processing, depending upon the complicated design process involving filter designs corresponding to different filter lengths has been done and its results have been presented. The factor K is called as Overlapping factor in the reference range(2,4,6,8,10,20) [2].Overlapping factor is defined as the number of multicarrier symbols which overlap in time domain.

II.FREQUENCY SAMPLING DESIGN TECHNIQUE

The prototype filter is designed to fulfill the Perfect Reconstruction Conditions to show NPR characteristics. But, it is worth to mention that PR property is obtainable if and only if the channel under consideration is a ideal transmission channel. It means at the interferences which arise from the filter bank structure are negligibly small as compared to the ultimate residual interferences due to transmission channel.Moreover,NPR prototype filters can provide higher stopband attenuation than their equal length PR counterparts.One way to design the NPR prototype filter is to directly optimize the coefficients of the impulse response.A major drawback of this technique is that the number of filter coefficients increases sharply when the filter bank is designed with number of subchannels greater than 256[3-4].The overlapping factor K=4 has been used in the core of the FBMC system.Also,a localized mode band allocation of Ms=160 subcarriers(subchannels) is assumed.

III.INTELLIGENT COGNITIVE RADIO NETWORK

This section concentrates on the frequency sampling design technique. In fact,FBMC Transceiver for multi user asynchronous transmission on the fragmented spectrum plays a key role in spectrum sensing in wireless cognitive radio networks though partially depending upon the requirements, challenges and design trade-offs whatsoever possible.So,the intelligence in the wireless cognitive radio networks can be introduced by spectrum sensing the bandwidth size and that too on multiple channels with different signal strengths and differing transmission types and timing windows[5].Good spectral containment is must for avoiding distortion from the asynchronous signals from adjacent bands.An important specification in digital transmission is the delay and there is always a strong need to minimize the delay of the prototype filter because the selection of the number of coefficients is a trade-off between delay and filter performance,mainly stop band attenuation[5-6].

IV.FILTER BANK PROCESSING FOR MULTIMODE TRANSMISSION

A Filter Bank Processing based uplink multiple access scheme enables different mobile terminals to transmit at a time in the reverse link at different operation modes including FBMC,FB-FBMC and conventional serial carrier modulation.It means this concept provides independent uplink signal multiplexes in bandwidth efficient manner.A reverse link supporting simultaneously both multicarrier and single carrier modes can be established by making use of the better selectivity of the frequency sampling designed prototype filter and a low computational complexity linear equalizer structure,which is capable of frequency selective per sub band processing facilitating both efficient channel and timing compensation[7]Even,the optimization and Implementation of Modified DFT Filter Bank Multicarrier Modulation Systems has been found to be quite useful for the design of modulation systems in the next generation mobile communication networks[8].

V.PRACTICAL ISSUES IN FREQUENCY SYNCHRONIZATION FOR FBMC TRANSMISSION

The higher stopband attenuation of Filter bank allows the channel selection filtering and Narrowband Interference Suppression directly at the receiver analysis bank,without any pre-processing,beside the anti-aliasing filtering determined mostly by the sampling rate at the analysis filter bank input.Since,the Filter Bank provides good frequency selection for the desired spectral components,so it is desirable to think of a FBMC receiver where all the baseband signal processing functions are performed in frequency domain.i.e after analysis filter bank.All the channel parameter estimation processing is done after analysis filter bank at a lower rate[9].The practical transmission systems are peak power limited and they show non-linear characteristics which also cause spectral widening of the transmit signal.It means that the present communication systems have to restrict the power spectral density of the transmit signal to correctly specified spectrum mask. In conventional OFDM system, the power spectral density is not nicely band limited due to the low stop band attenuation of the trivial subband filters. Hence, OFDM requires larger system bandwidth for same data rate.This problem is increased more due to additional guard band because applying a Cyclic Prefix and keeping the data rate constant leads to another unwanted increase in the required bandwidth .Another possibility to obtain equal data rates with same BW requirements for MDFT TMUX and OFDM system is to increase the modulation alphabet or the code rate of the channel codes in OFDM system [10].

VI.OFDM-OQAM

A better solution to the problems being persistent in OFDM system is to design filters and show that OFDM-OQAM i.e.FBMC offers highest stopband attenuation for a fixed filter length and a number of subcarriers.In order to keep the subcarrier bands, non-overlapping,excess bandwidth needs to be kept reserved to permit for a transition band for each subcarrier.Hence,OFDM-OQAM offers higher bandwidth efficiency and lower complexity.In OFDM-OQAM,subcarrier bands are spaced by the symbol rate,I/T.In comparison to the Filtered Modulated Multitone approach,this results in a significant overlap among adjacent bands.Complete signal separation is never possible and only remedy is the specific signaling arrangement.An introduced orthogonality between the subcarriers ensures that the transmitted symbols reach the receiver free from ISI and ICI.So,carrier orthogonality is achieved through time staggering the in-phase and quadrature phase components of the subcarrier symbols and designing proper transmit and receiver filters[11].

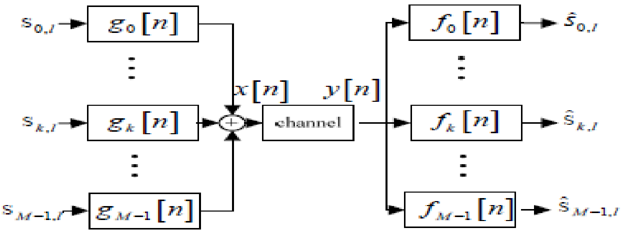

Figure 1. General Structure of an FBMC System[10]

The transmitted signal, $x[n]$, can be expressed as $x[n]=\sum\sum s_{k,l}\ g_k[n-lL_s]$ where M is the number of subcarriers, $s_{k,l}$ is the *lth* symbol in the *kth* subcarrier, Ls is the number of samples per transmit symbol spacing, and $g_k[n]$ is the synthesis filter for the *kth* subcarrier.At the receiver, the estimated *lth* symbol $s_{k,l}$ in the *kth* subcarrier is $s_{k,l}=(y[n]*f_k[n])$ where $n=lL_s$ where $y[n]$ is the received signal and $f_k[n]$ is the impulse response of the analysis filter for the *kth* subcarrier.We define the number of samples per symbol duration as *L*,where L > M.Note that *Ls* and *L* are not necessarily the same. For an ideal channel where y[n]=x[n], a QAM symbol $s_{k,l}$ in OFDM is same as the input symbol $s_{k,l}$ if the filter satisfies the orthogonal condition:$g_k[n-mL_s],f_i[n-lL_s]=\delta_{k,i}\delta_{m,l}$ where $\delta_{a,b}$ is Kronecker delta[12].

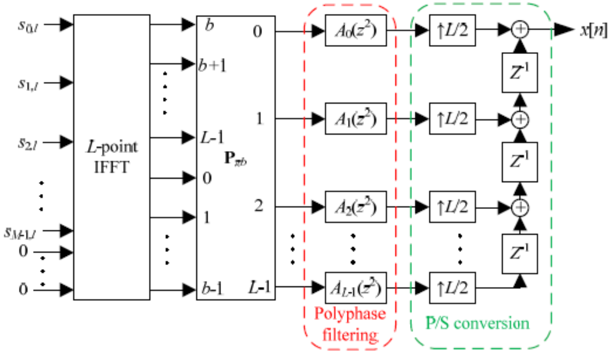

Figure 2 Polyphase Implementation of OFDM-OQAM SFB[11]

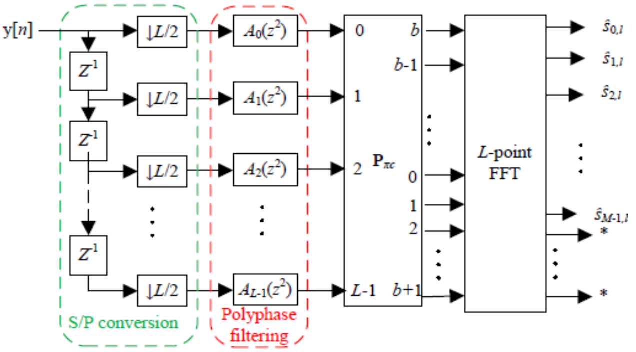

Figure.3 Polyphase Implementation of OFDM_OQAM AFB[11]

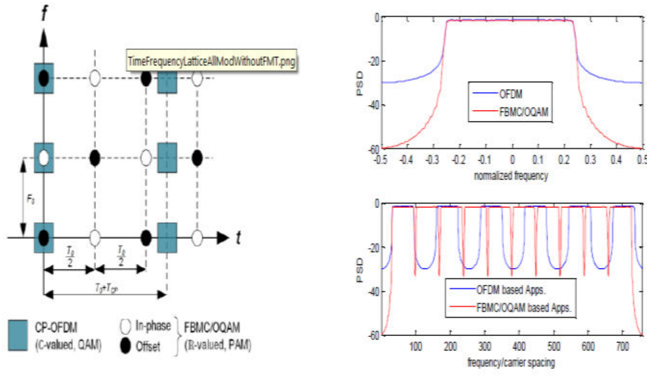

Figure.4(a)&(b) show Time/Frequency Lattice of CP-OFDM and FBMC ;Spectral Side lobes and Guard Band(Power Spectral density versus Normalized Frequency,PSD versus Frequency/Carrier Spacing)[12].

VII FBMC PROTOTYPE DESIGN

For a multi-carrier system, denote as the spacing between sub-carriers and as the symbol duration.The modulated signal can be written as a linear combination of a Gabor family, i.e. the triplet ,where *f* is the waveform pulse or prototype function.One can deduce that it is not possible to get a modulation scheme holding at the same time the property of (i) orthogonality in the complex field (ii) a well-localized pulse shape both in time and frequency and (iii) reaching maximum spectral efficiency by keeping Nyquist rate transmission.When CP-OFDM and FBMC/OQAM are compared in the time-frequency lattice representation, as shown in Fig.4(a) and (b),the CP-OFDM waveform meets the complex orthogonality property, but at the same time only has a poor localization in the frequency domain due to the Sinc-shaped spectrum of the pulse.It does not achieve maximum spectral efficiency due to the additional overhead of the CP.On the contrary,FBMC/OQAM schemes relax the complex orthogonality to real field only.Due to their pulse shaping design they can be better localized in time and frequency,eventually depending on the design of filter.With this flexibility,FBMC/OQAM is able to achieve the maximum spectral efficiency [13].

Currently,there are two major design criteria for the prototype filters in FBMC/OQAM systems, which are either the optimization of time-frequency-localization (TFL) or only frequency localization (FL).The TFL criterion aims to design a waveform that is well-localized both in time and frequency domain.When the radio coexistence and out-of-band leakage becomes an important metric,as foreseen for future mobile systems,FL criterion needs to be taken into consideration.Several algorithms have been presented for this criterion,e.g.the PHYDYAS filter [2] and the frequency selectivity algorithm [12].

VIII.FBMC/OQAM TRANSCEIVER

Now,we briefly discuss a part of the prior art in the following.

[1]Modem implementation:The efficient realization of subband filter chains for FBMC/OQAM is feasible by the use of polyphase networks [5].With the number of subcarriers, denoted N, the complexity of the FFT is growing with O(N logN). At the same time, the required subband filter grows with O(KN). Hence, with larger subchannel counts, the basic modulator complexity is only slightly increased in comparison to CP-OFDM schemes.FBMC/OQAM is the most popular filter bank scheme that introduces a half symbol space delay between the in phase and quadrature components of quadrature amplitude modulated(QAM) symbols.This filter bank scheme achieves maximum transmission rate. Moreover, the transmitter and receiver in this type could be implemented efficiently in a polyphase structure. FBMC is considered a potential candidate for the 5G air interface, as its inherent properties provide the flexibility needed to respond to the diverse service requirements expected in future communication systems[11-12].

IX. N-CHANNEL MULTIRATE FILTER BANK

According to Mohd Abo Zahhad et al[10],non –ideal filters could be used to split signal into different subband samples.Several aspects of N channel multirate filter banks pave the background for alias cancellation and the minimization of amplitude and phase distortions,ultimately achieving Perfect Reconstruction Property.The finite arithemetic and word length effects on the implementation of multirate filter banks have been reviewed.A filter bank is a set of filters operating in parallel,either in analysis mode with a single input or in a synthesis mode with multiple input and a single output.Fig.5. shows an N channel multirate filter bank where $H_k(z)$,$F_k(z)$ are analysis and synthesis filters.

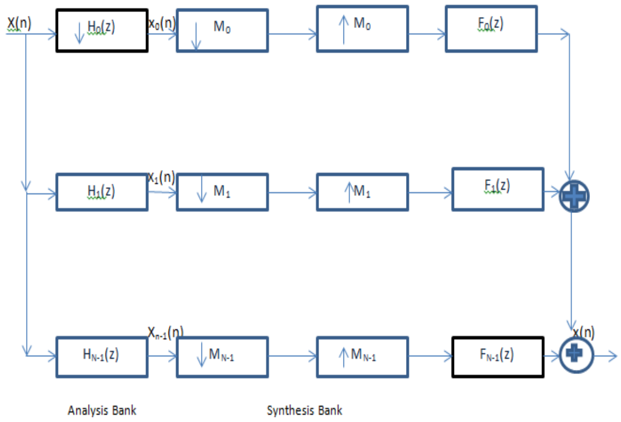

Figure.5. An N-channel Parallel Multirate Filter Bank[10]

Analysis filter bank processes the input signal into many subbands using a parallel set of bandpass filters while synthesis filter bank reconstructs the subband signals using a set of parallel filters.The types of these filters rely on the applicability of the problem.The N-channel multirate filter bank can be considered to be an extension to the two channel filter bank.Actually,the N filters in the analysis bank should produce as much isolation between the bands as possible and simultaneously should not tend to create any spectral gaps between the channels.The discrete version of the input signal x(n) is split into N subband signals $x_k(n)$ by the use of filters $H_k(z)$,$0<k<N-1$.Each of these subband signals is decimated by a ratio M_k and encoded.In order to reconstruct the original signal,the subband signals are interpolated to obtain the original sampling rate and then recombined through the set of synthesis filters $F_k(z)$,$0<k<N-1$.The down and upsampling factors generally differ from channel to channel based on the characteristics of analysis filter used in the channel.Other features to be considered in the design of multirate filter banks are widths and spacings of frequency bands,extent of allowed overlap of frequency bands and nature of reconstruction required.In case of maximally decimated uniform filter banks,the number of channels are equal to the decimation factor i.e.N=M.

X.ALIASING DISTORTION IN MULTIRATE FILTER BANK

A number of filter banks of type of arbitrary N have been designed in past years and the processes of distortion elimination have been investigated.In general,in M-channel maximally decimated filter bank,the input-output relation between X(z) and Y(z) is stated as

$Y(z)=1/M(\sum H_k(zW^n)F_k(z))X(z)+1/M(X(zW^n)\sum H_k(zW^n)F_k(z))$…Eq.1

Where.$W=e^{-j2\pi/M}$.If interpolators and decimators of the filter bank are removed then the input-output relation of the system is given by

$Y(z)=$
$1/M(\sum H_k(z)F_k(z))X(z)$………………………..Eq.2

From Eq.1 and Eq2, it is clear that terms corresponding to $1<n<M-1$ are the unwanted aliasing terms.Hence,alias free system has the following input-output relation

$Y(z)/X(z)=T(z)=1/M(\sum H_k(z)F_k(z))$………………Eq.3

Here T(z) is the overall transfer function indicating the amount of amplitude and phase distortions of the analysis-synthesis system.The necessary condition for the filter bank to be distortionless is that $H_k(z)$ and $F_k(z)$ should be designed in such a way that T(z) is a stable all pass function for nil amplitude distortion and T(z) also shows exact linear phase for nil phase distortion.The first condition is equivalent to power complementary axiom.i.e

$\sum I H_k(j\omega) I^2=1$……………………………………..Eq.4

The core part of the design process of such filters is to find a set of transfer functions $H_k(z)$ and $F_k(z)$ which satisfy the equation

$(1/M)\sum X(zW^n)\sum H_k(zW^n)F_k(z)=0$…………………Eq.5

$T(z)=1/M(\sum H_k(z)F_k(z))=cz^{-T0}$……………………..Eq.6

Practically,the exact original signal cannot be recovered due to the loss of information caused by coding and communication channel effects.In distortionless channel,it is possible to carry out a perfect reconstruction of signal with proper designed pair of analysis and synthesis filter banks.Here it is assumed that all the subband signals which are available to synthesis bank are free from distortion[10].

XI.PROTOTYPE FILTERCOMPUTATIONS

In order to avoid the Interference Problem,the channel must satisfy the Nyquist criterian.If the symbol period is Ts and the symbol rate is fs=1/Ts, the channel frequency response must be symmetrical about the frequency fs/2.Hence,in FBMC system,the prototype filter for synthesis and analysis filter banks must be half-nyquist,which means that square of its frequency response must satisfy Nyquist criterian.The design of prototype filter must satisfy Perfect Reconstruction conditions or at least achieve Nearly Perfect Reconstruction Characteristics. But, the Perfect Reconstruction Property is only achievable with ideal transmission channel.As wireless channel non-linearities are unavoidable,so there is no way to have PR conditions. Thus, Prototype filters are said to exhibit NPR characteristics.The impulse response coefficients of the filter are obtained according to the desired frequency response,which is sampled on KM uniformly spaced frequency points[11-13].Both efficient transmitter and receiver structures of an FBMC system are composed of the filtering through M parallel polyphase components working at twice the symbol rate,by an FFT/IFFT also working at twice the symbol rate and, at the receiver, by the linear equalizers also working in T/2, where 1/T is the QAM symbol rate.At the transmitter the FFT has in its input pure real or pure imaginary symbols due to the OQAM modulation and for that reason the transform has a reduced complexity when compared to the case where all inputs are complex numbers. As a result, the number of real multiplications needed to generate one complex output sample at the transmitter is given by [14-15].

CSFB=M($\log_2$(M/2)−3) + 8 + 4(MK + 1)…………Eq.7

The number of real additions is ASFB = 3M($\log_2$(M/2) −1)+8+4(MK −M + 1)……………………………Eq.8.

The receiver uses an FFT with complex inputs and outputs, resulting in a multiplication complexity equal to CAFB=2M($\log_2$(M)−3)+8+4(MK + 1) + 4L_{eq}…Eq.9 where L_{eq} is the length of the equalizer.The number of real additions is in this case is given by

AAFB=6M($\log_2$(M)−1) + 8 + 4(MK −M + 1)….Eq.10

That said the total number of real multiplications for each information bit is given by

CFBMC=[CSFB+ CAFB + 4L_{eq}Mf]/Ni= [M(3 $\log_2$(M) −10)+16+8(MK + 1)4L_{eq}Mf]/Ni…………………Eq.11

Similarly, the number of real additions is given by AFBMC=[ASFB+AAFB+(4L_{eq}−2)Mf]/Ni=[M(9$\log_2$(M)−12)+16+8(MK−M+1)+(4L_{eq}−2)Mf]/Ni………Eq.12

Below shown is the Analytical Mathematical Expressions of Most prominent PHYDAS Prototype Filters available in Literature[2].

$$p_{\text{phydyas}}(t) = \begin{cases} 1 + 2\displaystyle\sum_{k=1}^{K-1} a_k \cos\left(2\pi \frac{kt}{Kt}\right), & -\frac{KT}{2} \le t \le \frac{KT}{2}, \\ 0, & \text{otherwise} \end{cases}$$

$$P_{\text{phydyas}}(f) = \sum_{k=-(K-1)}^{K-1} a_k \frac{\sin\left(\pi\left(f - \frac{k}{MK}\right)\right)}{MK \sin\left(\pi\left(f - \frac{k}{MK}\right)\right)}$$

Table.1 PHYDAS Prototype Filter Equation available in Literature[2].

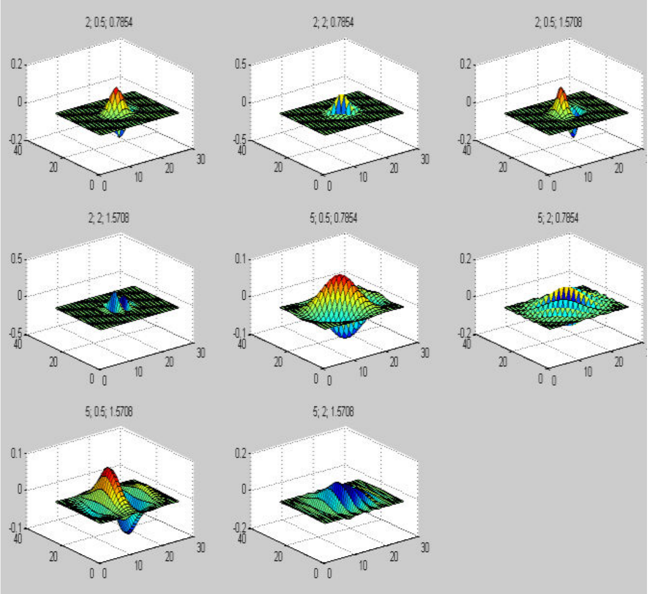

Figure.6 Different 3D Mesh plots for Gabor Kernel/Lattice Structures for FBMC.

XII. FLOWCHART FOR THE COMPUTATION OF NEAR PERFECT RECONSTRUCTION FILTER COEFFICENTS

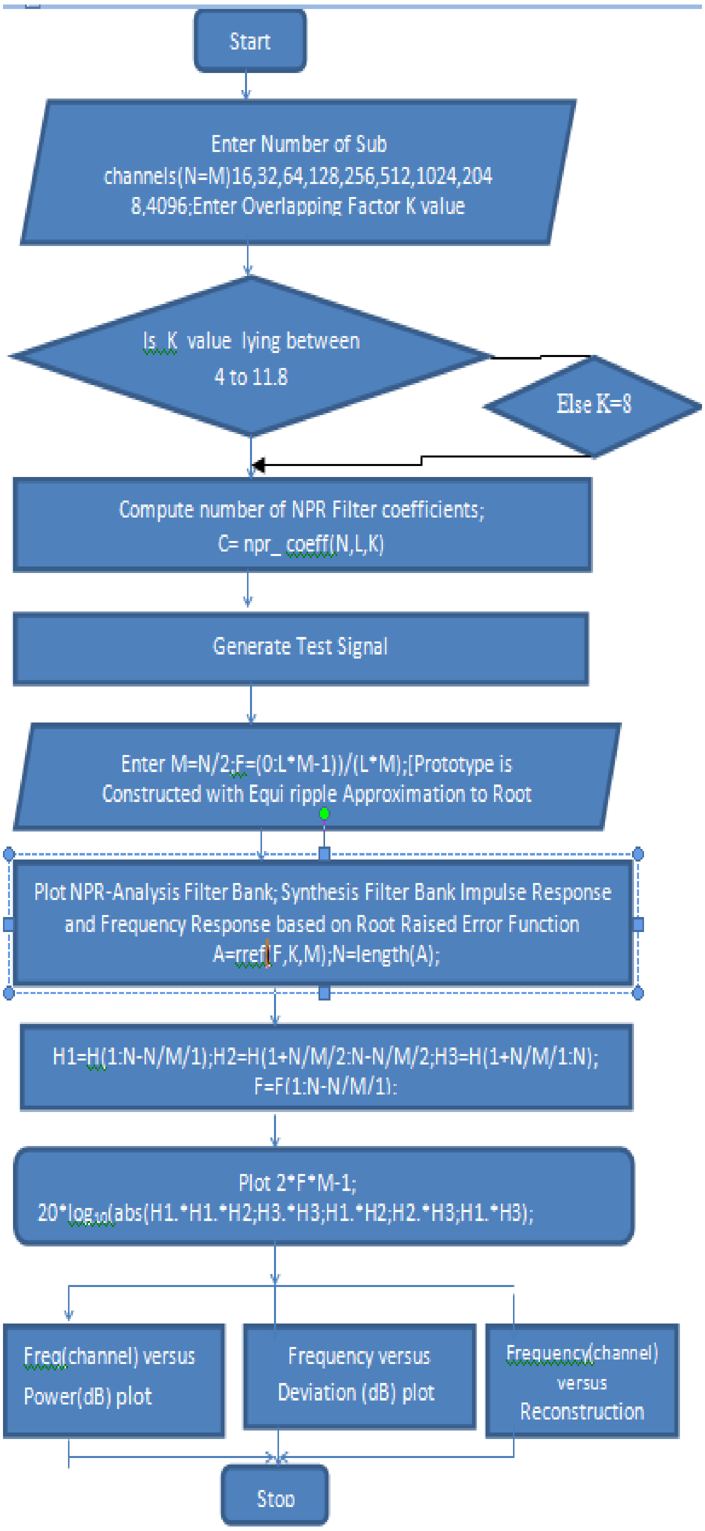

Figure.7 Flowchart for NPR Filter Bank

A Flowchart for Design of NPR Polyphase Filter bank Under the Effect of Different Parameters has been given below.

XIII.RESULTS & DISCUSSION

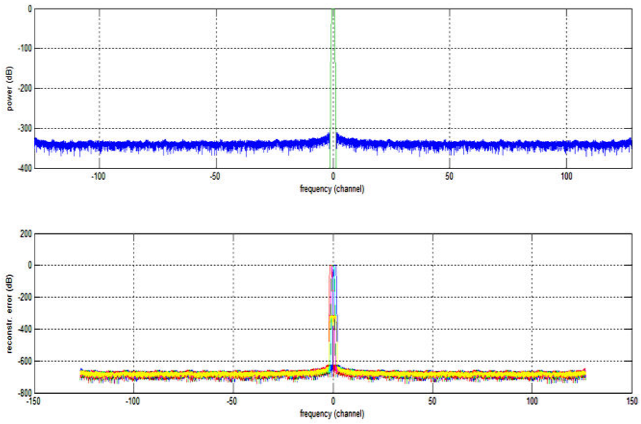

Figure 8.Power versus Frequency and Reconstruction Error versus Frequency plot at L=128,M=256,K=11.4

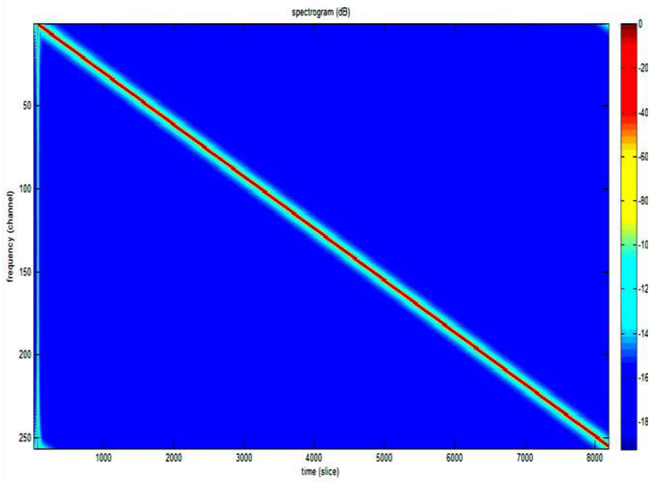

Figure 9.Frequency Time Spectrogram at K=4,M=4096

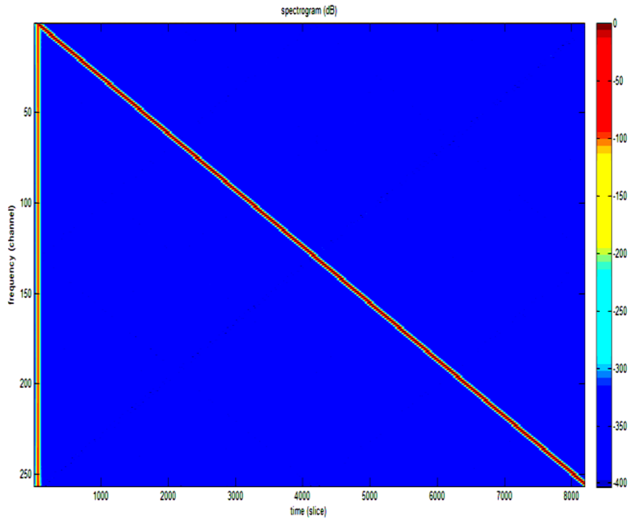

Figure.10 Frequency Time Spectrogram at K=11.4,M=4096

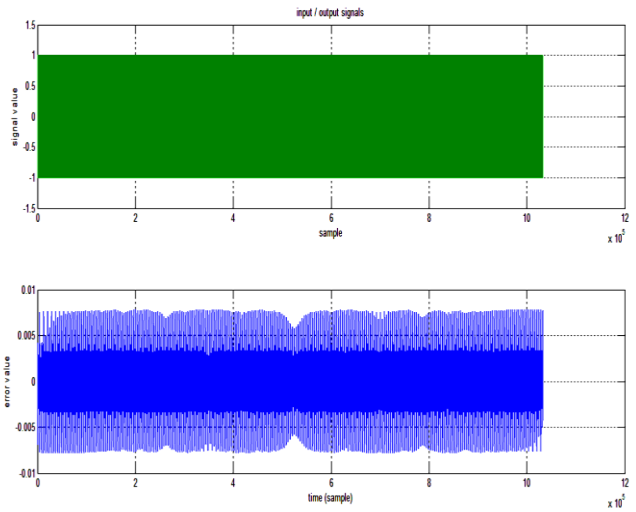

Figure.11 Signal value versus sample and error value versus time(sample) at K=4,M=4096

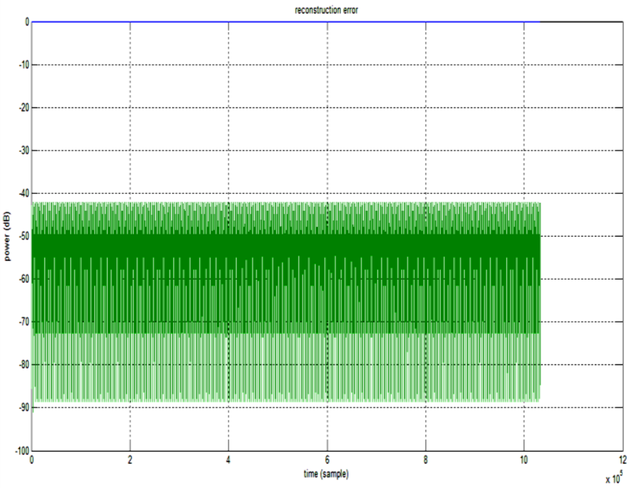

Figure.12 Power(dB) versus time(sample) reconstruction error at K=4,M=4096

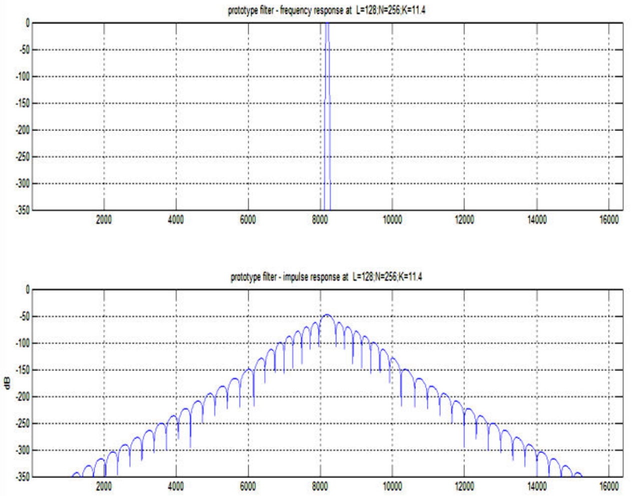

Figure 13. Prototype Filter Frequency Response and Impulse Response at L=128,N=256,K=11.4

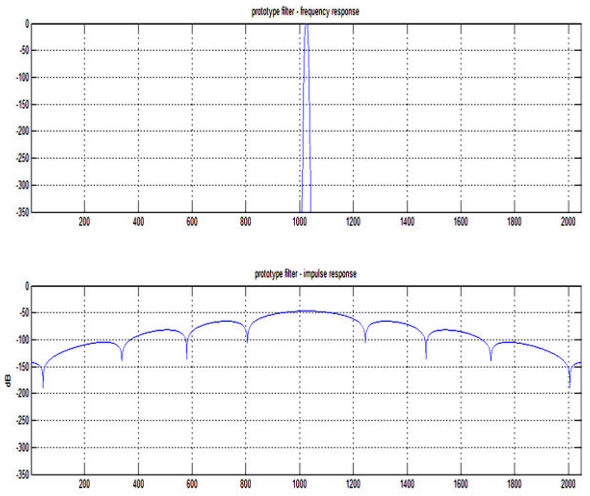

Figure.14 Prototype Filter Impulse Response and Frequency Response at L=16,N=256,K=4.8

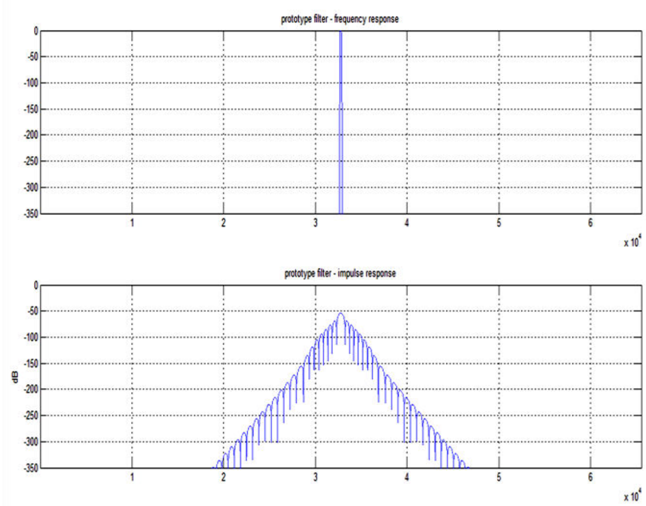

Figure.17 Prototype Filter Impulse response and frequency response at L=256,N=512,K=5.2

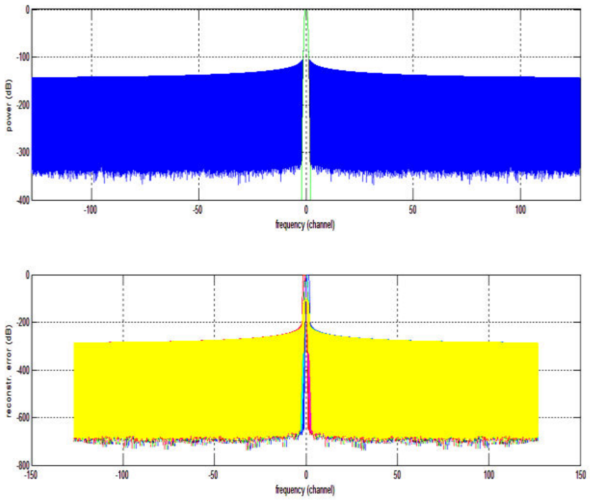

Figure.15 Power versus Frequency and Reconstruction Error versus Frequency Plot at L=16,N=256,K=4.8

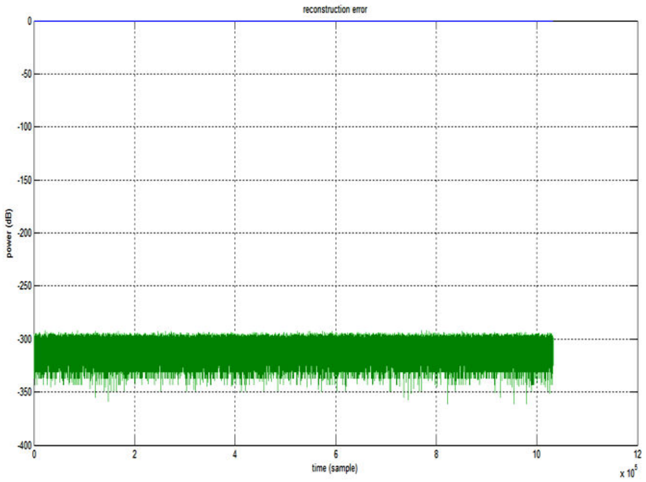

Figure.18.Power versus Reconstruction Error at K=11.4,M=4096,L=128

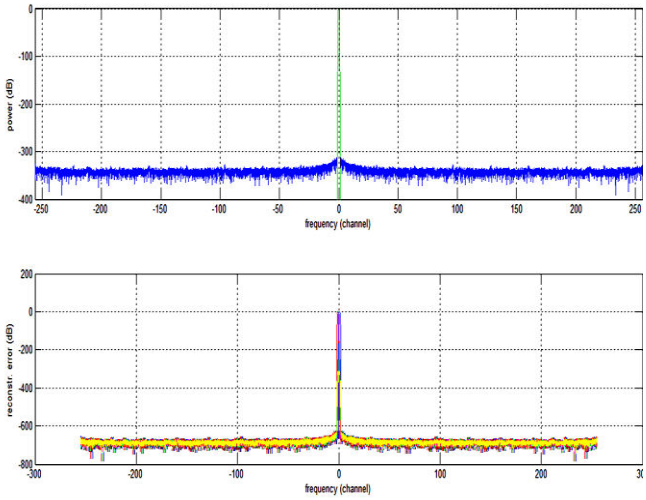

Figure 16.Power versus Frequency and Reconstruction Error versus Frequency Plot at L=256,N=512,K=5.2

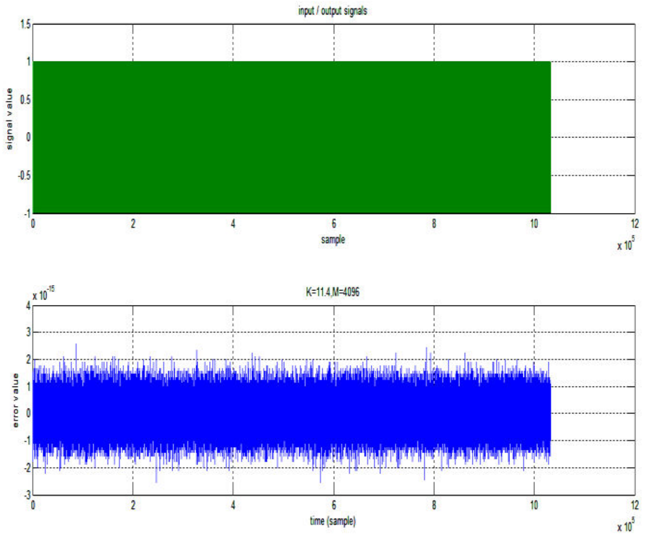

Figure.19 Signal error value versus time sample at K=11.4 and M=4096

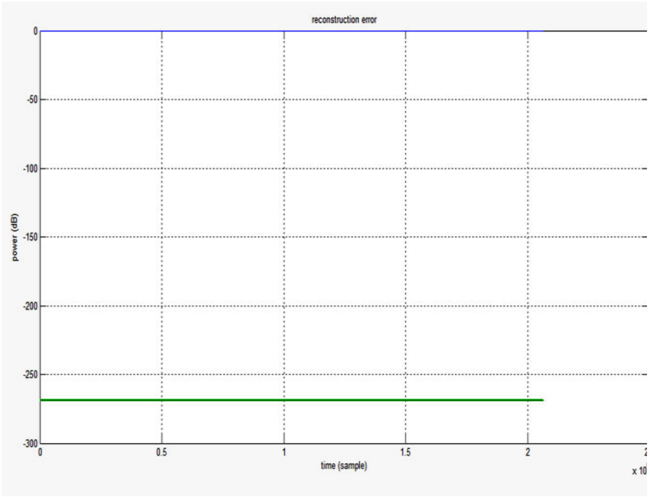

Figure.20.Power(dB) versus time(samples) for K=11.4,M=512,L=128

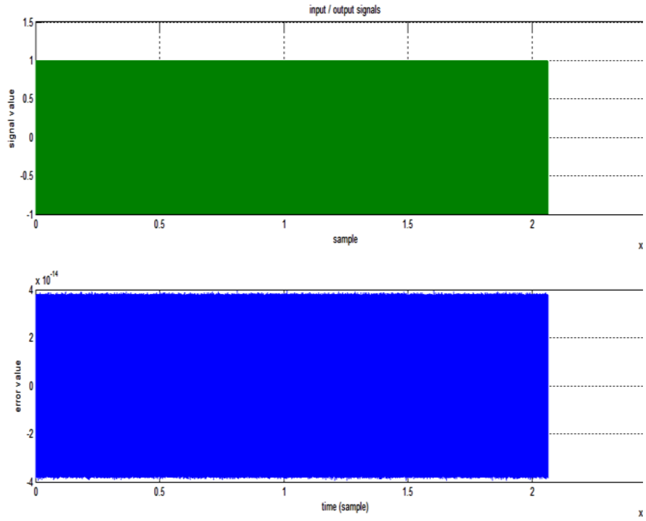

Figure.21 Signal value versus sample and error value versus time(sample) for K=11.4 and M=512,L=128

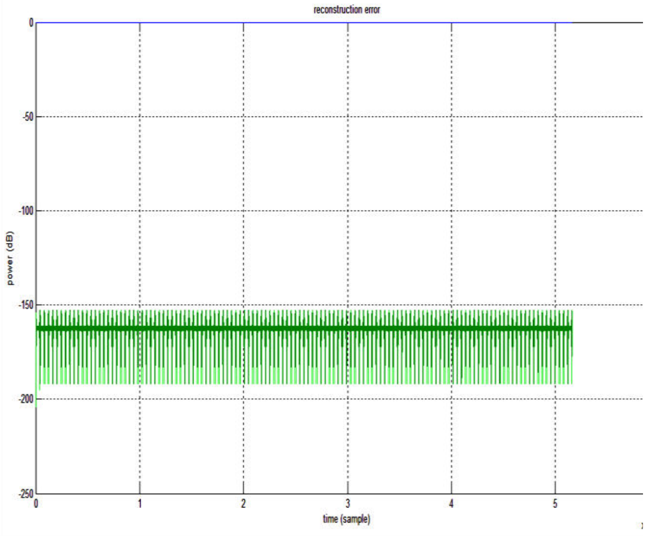

Figure 22 Power versus time(sample) for K=8 and M=128,L=128

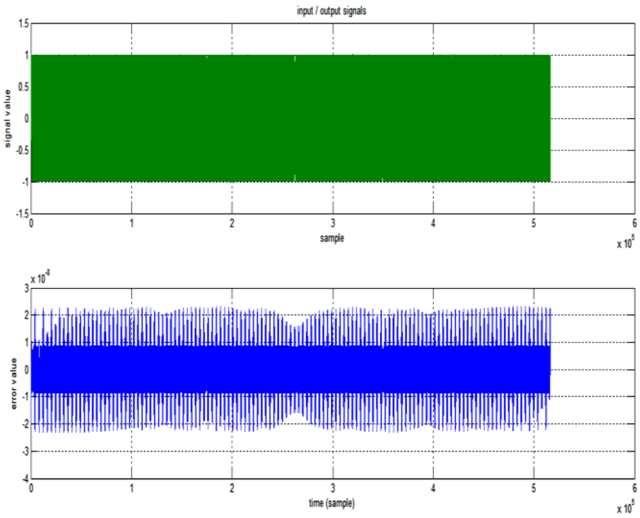

Figure.23 Signal Value versus sample and Error value versus time(sample) for K=8 and M=128

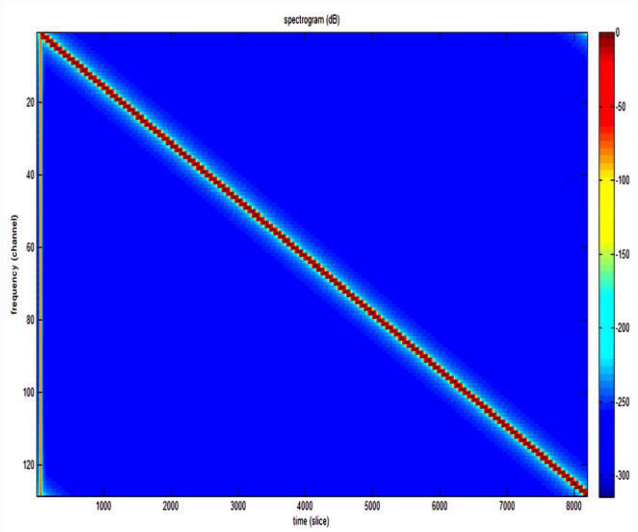

Figure.24 Frequency Time Spectrogram at K=8,M=128

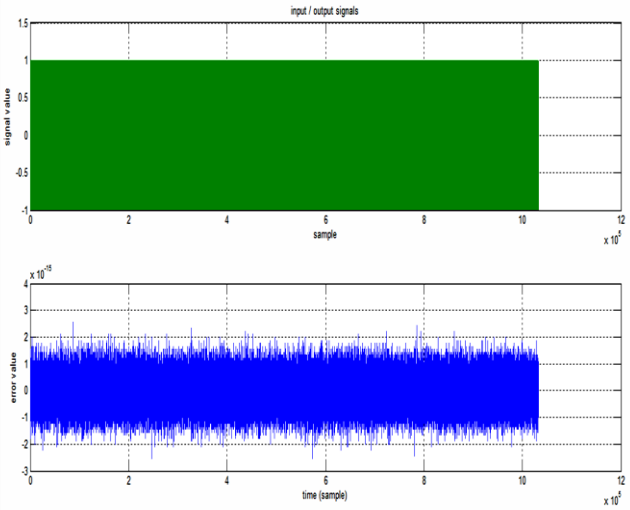

Figure.25.Signal Value versus sample and Error value versus time(sample) for K=11.4,M=256

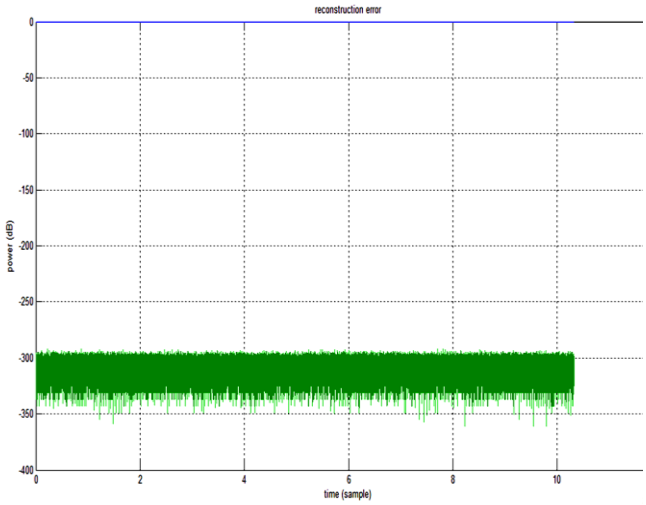

Figure 26. Power versus time(sample) for K=11.4,M=256

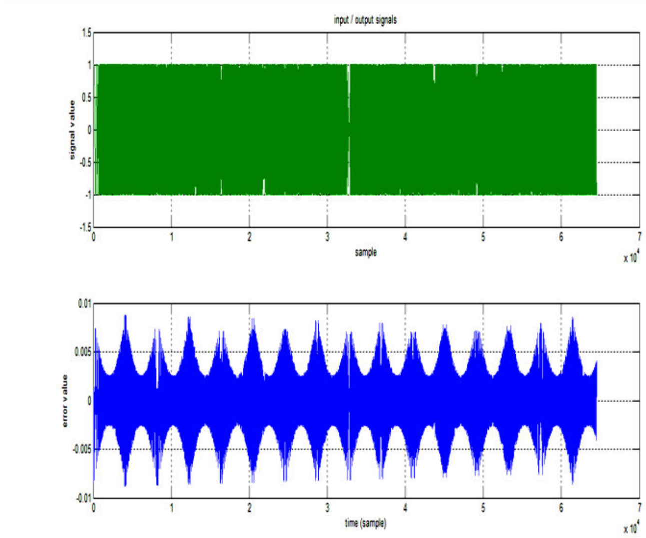

Figure.27 Signal value versus sample and error value versus time(sample) for K=4,M=16

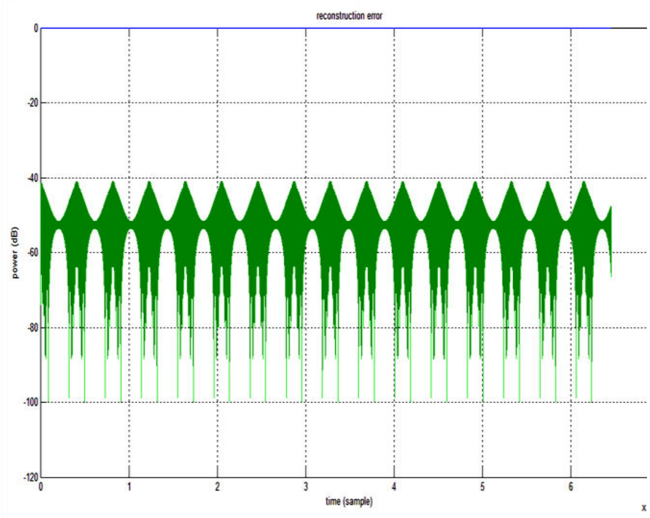

Figure.28 Power(dB) versus Reconstruction error for K=4,M=16

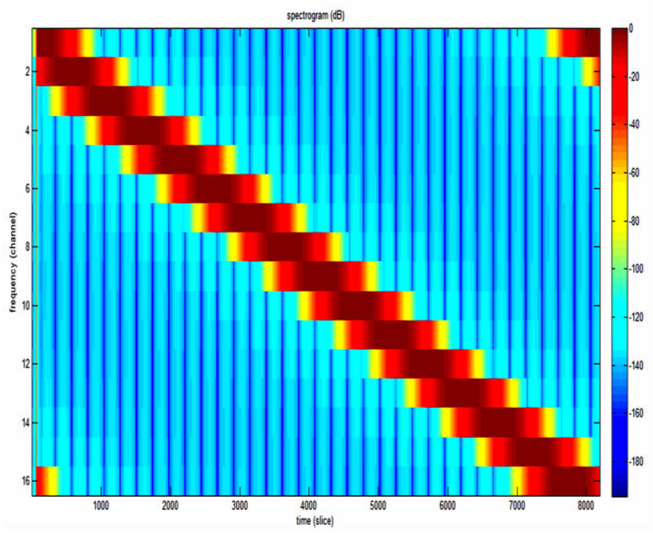

Figure.29 Frequency Time Spectrogram for K=4,M=16

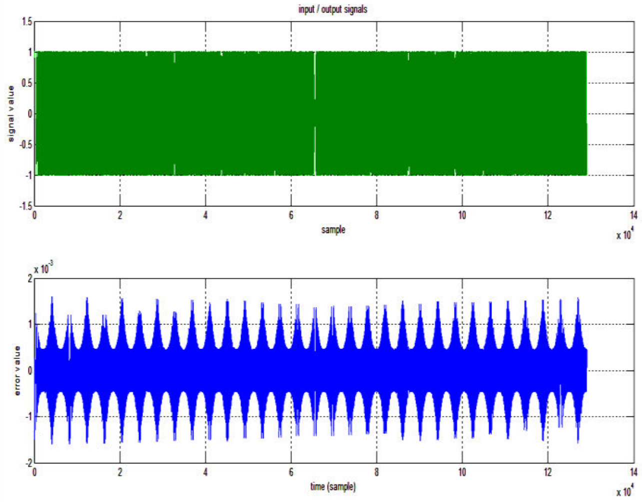

Figure 30 Signal Value versus Sample and Error Value versus Sample at K=4.7,M=32,L=128

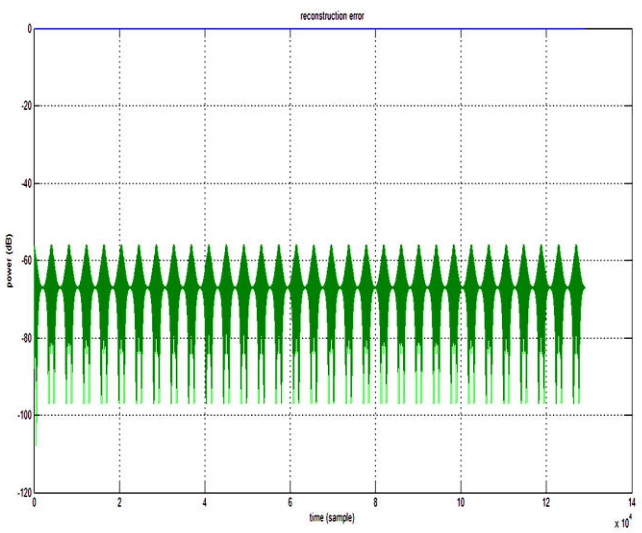

Figure 31 Power(dB) versus time(sample) at K=4.7,M=32

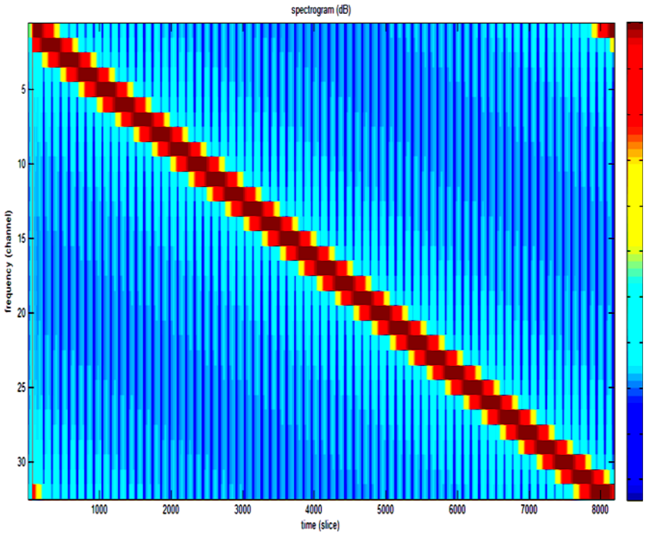

Figure 32 Frequency-Time Spectrogram at K=4.7,M=32

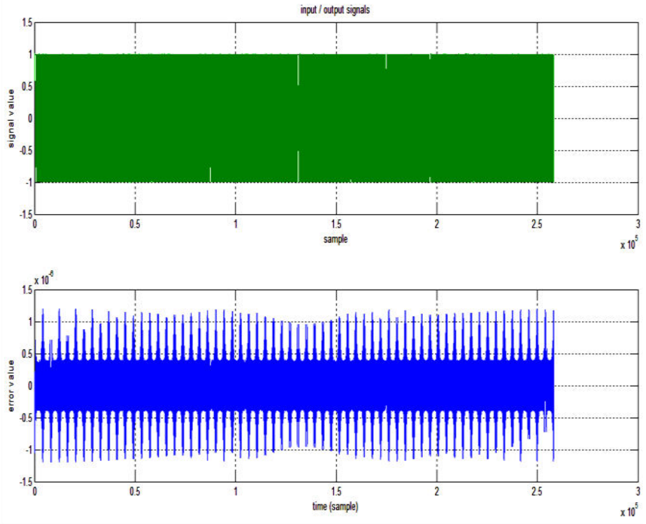

Figure.33 Signal Value versus Sample and Error Value versus time(sample) for K=7,M=64

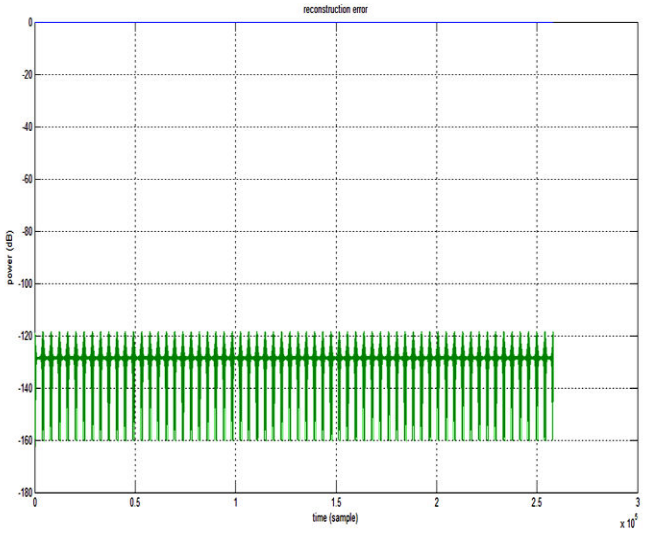

Figure 34 Power(dB) versus time(sample) for K=7,M=64

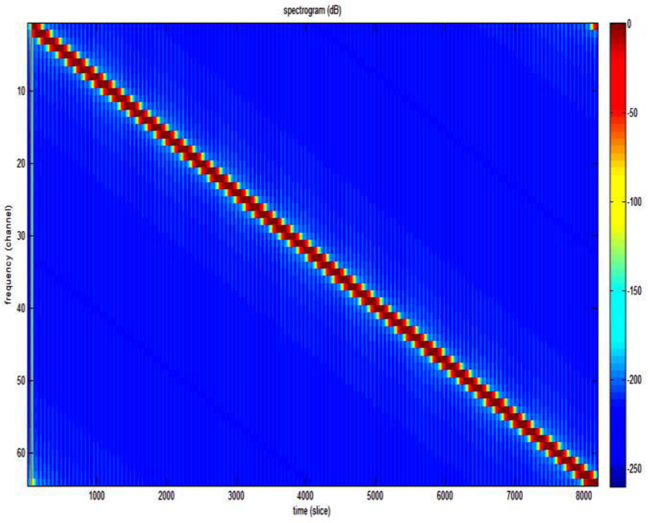

Figure 35 Frequency Time Spectrogram at K=7,M=64

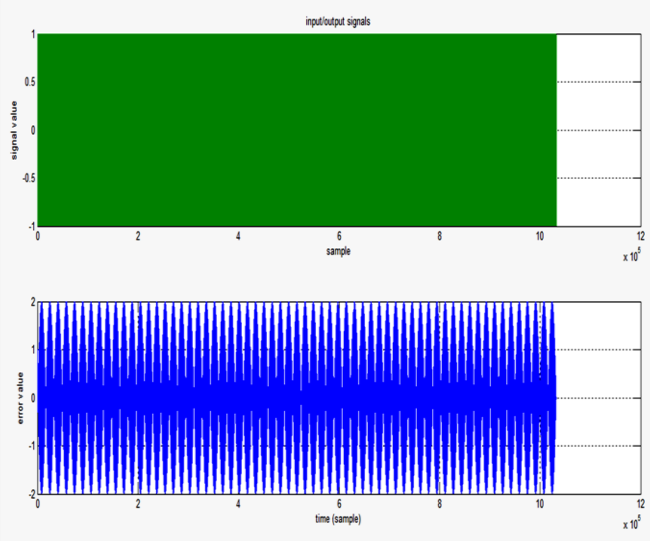

Figure.36 Signal value versus sample and error value versus time(sample) for K=11.4,M=256

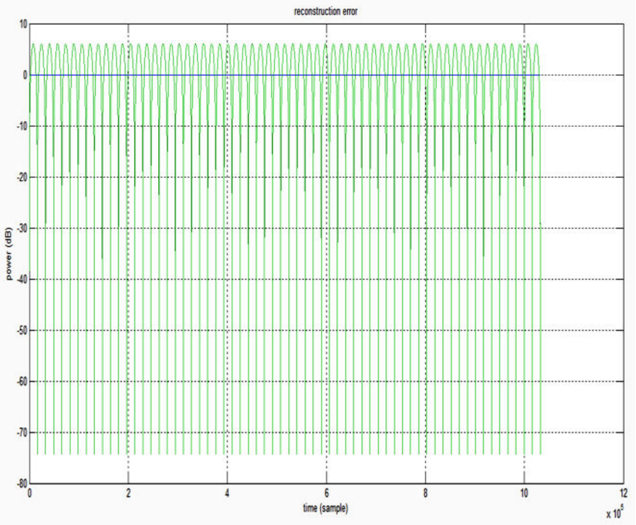

Figure.37 Power(dB) versus time(sample) for K=11.4,M=256

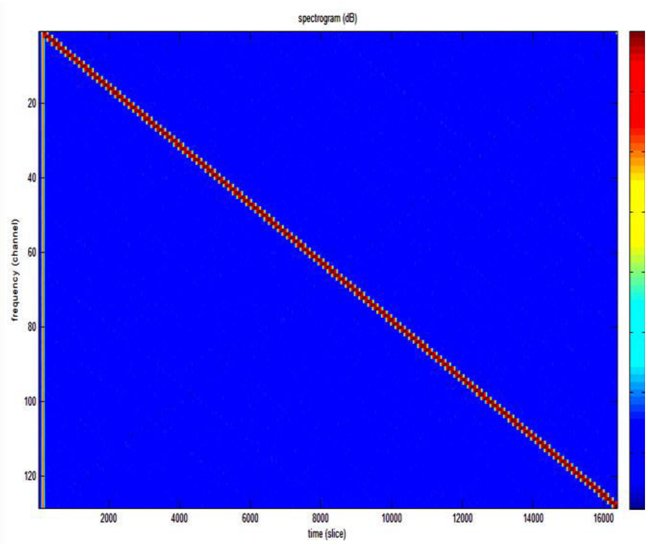

Figure.38 Frequency-Time Spectrogram for K=11.4,M=256

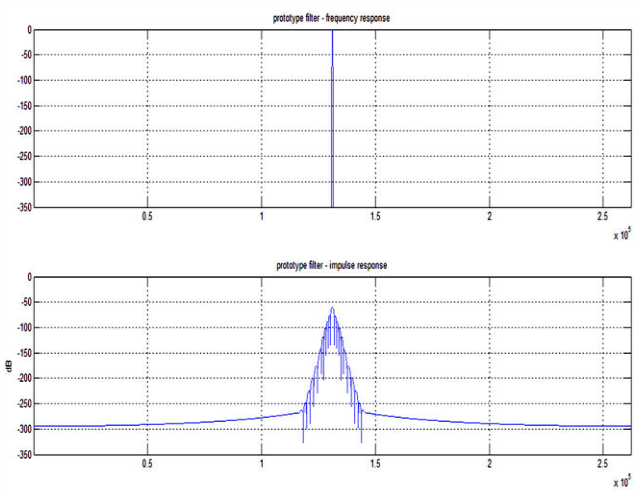

Figure.39 Prototype Filter Frequency Response and Impulse Response at L=512,N=1024 at K=7

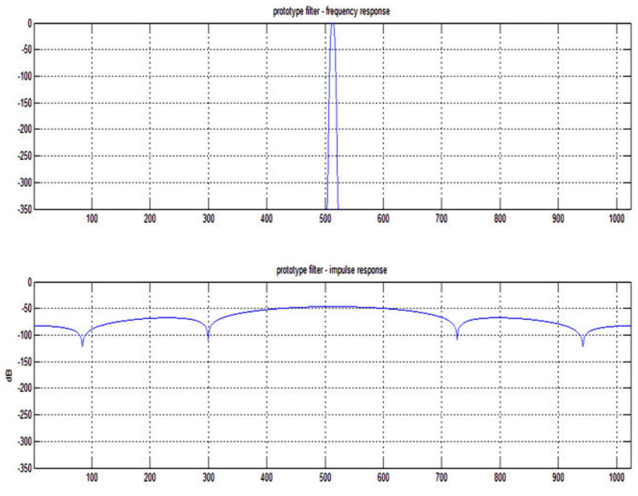

Figure.40 Prototype Filter Frequency Response and Impulse Response at L=8,N=256,K=4.8

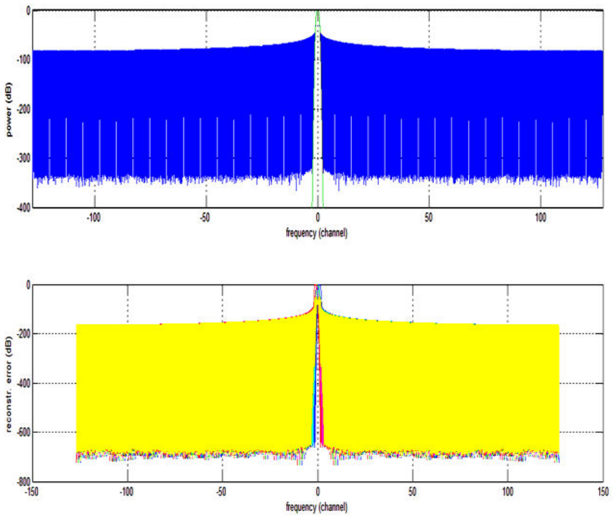

Figure.41 Power versus Frequency and Reconstruction Error versus Frequency plot at L=8,N=256,K=4.8

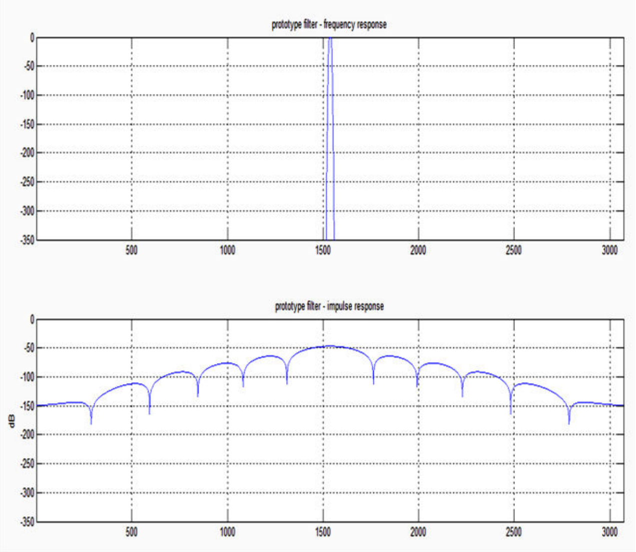

Figure.42 Prototype Filter Frequency Response and Impulse Response at L=24,K=8,N=256

Table.2 Computation of Power, Error value, Signal Value, Perfect Reconstruction Error, Test Signal Generated & Processing Rate for NPR–FBMC Design.

K	M	Lp=K*M-5	Lp=K*M +5	Power	Error Value(max,min	Signal Value	Perfect Reconstruction Error(dB)	Test Signal Generated	Processing Rate=%f*k samples/second
4	4096	16379	16389	-45db to -85db	$0.0075*10^5$	-1 to +1	-84	16777216	764.904460
4	16	59	69	-42db to -85db	$0.080*10^4$ to $-0.080*10^4$	$2*10^4$	-49.799	65536	700.166452
4.7	32	145.4	155.4	-58db to -99db	$-1.5*10^4$ to $1.5*10^4$	$2*10^4$	-64.600	131072	933.555269
7	64	443	453	-120db to -160db	$1.2*10^{-6}$ to $-1.2*10^{-6}$	$2*10^5$	-126.934	262144	800.190231
8	128	1019	1029	-150db to -180db	$2*10^{-8}$ to $-2*10^{-8}$	$2*10^5$	-160.79	524288	819.707066
11.4	512	5831.8	5841.8	-270db	$4*10^{-14}$	$2.1*10^6$	-268.64	2097152	742.718004
11.4	4096	46689.4	46699.4	-300db to -340db	$1.5*10^{-15}$	$1*10^5$	-13.3	16777216	769.832262
11.4	256	2913.4	2923.4	-350db	$-1.8*10^{-15}$ to $+1.8*10^{-15}$	$2*10^5$	-305.19	1048576	819.707066

Table.5.21 .K values corresponding to L values for NPR Multirate Filter Bank in Cognitive radio.If K value is not specified,then take Default Value**.**

L value(Number of Taps per Channel M) for NPR Polyphase Multirate Filter for Cognitive radio	**Following K values have been tested to minimize the Reconstruction Error**
8	4.853
10	4.775
12	5.257
14	5.736
16	5.856
18	7.037
20	6.499
22	6.483
24	7.410
26	7.022
28	7.097
30	7.755
32	7.452
48	8.522
64	9.396
96	10.785
128	11.5
192	11.5
256	11.5
512	8

XIV.CONCLUSION

In the present paper, the performance analysis of NPR Filter in cognitive radio has been done. An attempt on NPR Filter bank has also been made and to ensure the acceptable performance of Modified and Enhanced FBMC,computational complexity,system delay and transmission burst length need to be minimized/reduced. A fast and parallel algorithm with unified structure approach for FBMC Transceiver have been proposed.The unique feature of FBMC technique is its capability to provide improved frequency selectivity through the use of longer and spectrally efficient prototype filter.

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