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Cyclo-Stationary Based Spectrum Sensing of Interleaved SC-FDMA Signals

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Abstract: ***Our topic of interest here is about the cyclostationary detection of SC-FDMA signals. Such signals are usually transmitted in blocks and shows efficiency in performance at the cost of increased complexity. The processing technique called FFT used to make it to use it for multiple accesses and while speaking about advantages it has low PAPR. The SC-FDMA can be localized or interleaved and subcarriers are non-continuous in first and continuous in second case. We just concentrate on second one now. On our special concentration on second classification is due to advantages of having showing high frequency diversity and low PAPR. Also it shows the quasi-periodic patterns, i.e. it is the periodic replica of the original one. While at the same time there is a specific phase shift between the signals of different users. With all this we are able to establish some kind of relationship between the signals of different users. Then apply the Gaussian approximation by calculating the mean and variance of this under the existence and non-existence of the licensed users. To verify its correctness, they need to go through the Neyman-Pearson test. And finally the simulations performed shows their effectiveness which has to be analysed for both the AWGN as well Rayleigh channels. To show our superiority we need to compare it with the energy and auto-correlation based detections even at the penalty of complexity.***
Keywords: ***Cyclostationary detection, FFT, SC-FDMA, Gaussian Approximation, Neyman-Pearson test***

I. INTRODUCTION

My area of interest is in wireless communication and in particular the spectrum sensing and its detection methodologies. Really the persistent endeavors in the field of WC have been centered on improving the transmission rate to oblige different sorts of multimedia. Be that as it may, the simultaneous transmission of high information rate clients looks inconceivable because of the inalienable impediments of the accessible spectral range. Active research in the area of CR is been going on to properly use the available spectrum. Cognitive radio (CR) is conspicuous answer for managing the EM spectrum shortage situation. In this strategy, the spectrum is shared between licensed and unlicensed users. The former groups, which are also known as primary users (PU), are given priority to occupy the available spectrum. Then unlicensed users can use the channel only if it remains free. Hence there important task is to find whether subcarriers are free and when do licensed people need them. In a more meaningful way, we need to think more sensibly so as to utilize the gaps between the channels to be used by the SU. By this we can save time which is otherwise wasted waiting for PU to free the subcarriers. While doing such things we need to avoid the clash between both the licensed/unlicensed ones.

II. PROBLEM STATEMENT

The present day struggle in the field of communication is how to efficiently use the spectrum. As the spectrum is scarce resource, research is going on to develop the methods to intelligently reuse the available one. As the government is allocating only limited bandwidth to service providers, it is their responsibility to efficiently use that by introducing the alternate technologies. At early stages use of cells and frequency reuse was enough for low bit rate applications. But due to demand for multimedia applications now-a-days, those techniques never work out. This urge paved the way for introduction of spectrum sensing and their detection schemes.

III.METHODOLOGY

As we already discussion we are going to develop an effective detection methodology for SC-FDMA signals in which case the subcarriers are allocated continuously. Then the better technique can be build by exploiting the cyclostationary features. Then the process will continue by applying the Gaussian approximation for the technique and verify its working for existence as well as non-existence of the licensed users and also to carry out the Neyman-Pearson test. Thus our task is said to be completed when practical and theoretical things match. The same kind of analysis is done for AWGN and Rayleigh channels. Our task is not completed yet and we do need to continue by altering the length of data block, user quantity, window length and also effectiveness of pilot signals.

Then continue on doing the task with the comparative analysis with other detection methods. At last show practically with simulations that our method can perform better at even low SNR. In terms of exactness, the figure is 8-11db lower than others.

IV. SPECTRUM SENSING AND COGNITIVE RADIO NETWORKS

A. Spectrum sensing

The area of spectrum sensing deals with searching for unused frequency bands in the available spectrum so it can be efficiently used by the users waiting for the services in the queue. In other words, it periodically monitors the spectrum to check the availability of primary users else the free band can be assigned to the secondary users. Also we can tell it's a spectrum analyser technique. By this, we can utilize the spectrum efficiently. Due to increasing demand for spectrum allocation, service providers are encouraging research in this area to find new methods of efficiently utilizing the spectrum. It is not only designed to allow the secondary users to use the channels when the licensed users are available to use, but it allows switching between the bands when the environmental conditions of the present band do not favour the current transmission. This problem is encountered in case where there are problems like fading and attenuation affect the channel. Although this is advantageous in one point of view there are some defects with this technique too.

1) Energy Detection: The concept of energy detection was introduced in the year 1967. This detection strategy is applicable to every system due to its simplicity and do not require any primary user's information. This method is immmune to noise fluctuations and shows bad performance in low SNR scenerios. However the selection of peak point of energy remains a big challenge. The received signal is given by,

$$y(n) = s(n) + w(n)$$

Then threshold metric will be:

$$M = \sum_{n-0}^{N} |y(n)|^2$$

The decision is made using the following two hypotheses:

$$H_0: y(n) = w(n)$$
$$H_1: s(n) + w(n)$$

The performance of this scheme is analysed by plot of Pf versus Pd .The W, S have zero mean with variance σ_{w^2} $and\ \sigma_{s^2}$, with the metric following the chi-squared distribution. The selection of peak point of energy in turn depends on noise variance, whose estimation from autocorrelation of received signal is significant else may result in degraded performance. Selection of peak points of energy can be done through iterations. Also we can have to consider the fading and shadowing in case of practical scenarios.[5]

2) Waveform based sensing: This methodology relies on utilizing the pilot signals, which are the signals with specific patterns. Pilot signals are meant to provide channel estimation and synchronization. Other fixed patterns used are preamble, spreading sequences. Such patterns allow correlating the received signal with it for sensing. In this case, the decision metric will be,

$$M = \begin{cases} Re\left|\sum_{n=1}^{N} y(n)\, s^*(n)\right|, if\ H_0 \\ Re\left|\sum_{n=1}^{N} w(n)\, s^*(n)\right|, if\ H_1 \end{cases}$$

3) Matched Filtering: This method can detect the primary user with high clarity with a penalty of requiring the full information about the primary user signalling. Hence they can be demodulated to acquire the knowledge of modulation scheme, pulse shape, etc., Optimum method is the one which has complete knowledge of the transmitted signal and within short time reaches the given Pf. The number of samples increases as 1/SNR. [2]

4) Radio Identification Based Sensing: This scheme is based on knowing the particular transmission technology used which in turn makes us to know about the spectrum characteristics. This needs to communicate with the primary system sometimes. Identification depends on features like detected energy, BW, cyclic frequencies and SCD. Also called as feature detection relies on identifying the some of the statistical characteristics like the PU signal's covariance.

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5) Cyclostationarity-Based Sensing: This feature depends on periodicity of the signal else sometime we have to introduce into it. For detection purpose we need to use the CSD. For WSS noise, cyclic signal can be easily detected, with the detection metric being, [2][5]

$$CAF: R_{y^n}(\tau) = E\left[y(n+\tau)y^*\left(n-\tau e^{-j2\pi\alpha n}\right)\right]$$

$$CSD: S(f,\alpha) = \sum_{\tau=-\infty}^{\infty} R_{y^n}(\tau)e^{-2\pi f t}$$

6) Comparison of Sensing Schemes: [2] [5]

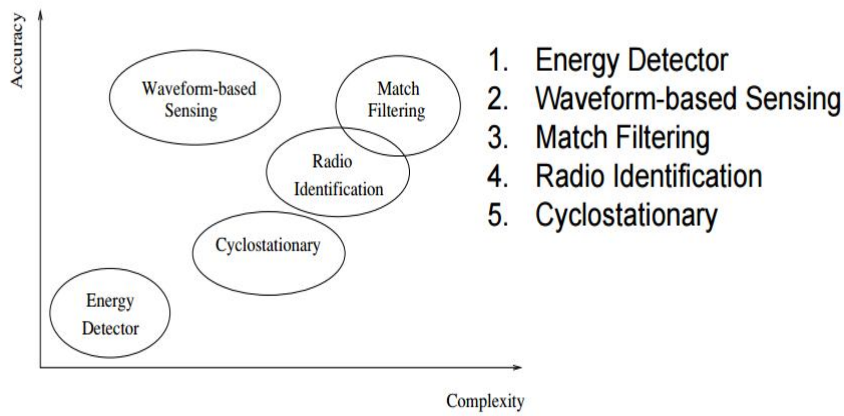

Fig 2 Accuracy Vs Complexity Graph of Various Sensing Methods

B. Cognitive Radio Networks

It is a form of wireless communication which is designed to detect channels in use and move into the one which is freely available intelligently. It is a radio programmed to enable us to use the best channel. In other words, it is intelligent radio technique that detects the free channels and when the parameters of the present channel do not suit the transmission, it allows switching to free channel and thus improving the transmission. It can be simply defined as a radio to sense the EM environment and adjust the operating parameters to improve throughput, minimize interference and allowing interoperability.[1]

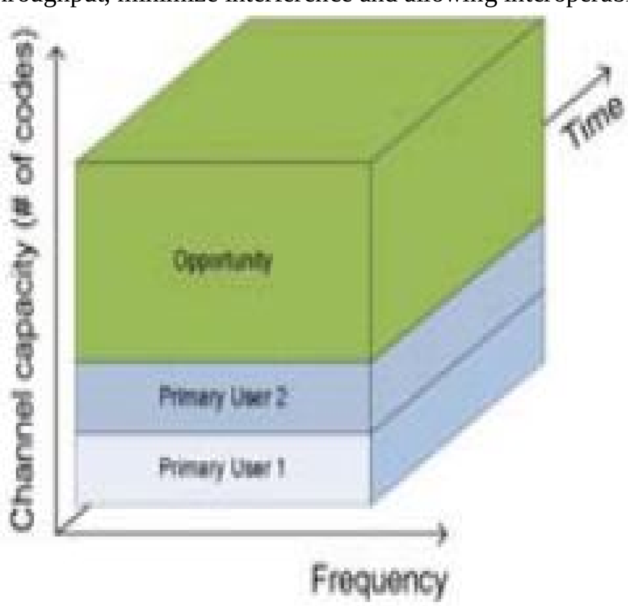

Fig 1 Efficient Use of Spectrum by Secondary Users When Primary Users Not Using the Spectrum

C. Interleaved SC-FDMA

There are two ways to map the M symbols from the output of FFT to the input of IFFT. First way can be called localized SC-FDMA uses M subcarriers of the IFFT and Zero-pad the other ones. The second way called distributed SC-FDMA distributes the subcarriers over the entire BW and uses zeros for the unused ones. [2][5] Interleaved SC-FDMA is the special case of second way in which the distribution of subcarrier is even over the entire BW and the separation between the subcarriers is equal to number of users. While comparing both the methods we can conclude that second method is advantageous in terms of lower PAPR and frequency diversity. By using any good resource allocation technique to the subcarriers, the equivalent performance can even be achieved with the first method too. With this we are assigning the best propagation characteristics to each of the terminals. The advantages associated with the second method can be comparable with the OFDMA and this makes it to be used for uplink MA scheme in LTE. By using power amplifiers, we can increase the coverage at the same time reducing the power consumption. These features make it to be used in compactable device.

V. OUTCOMES & COMMENTS

The best effort we put on our project can be felt only when the outcomes are positive. The results should not only satisfy us but also the one who reviews it. Hence the possible results in the visual form can make others to understand our project very easily. Visualizing them can create a better interest for the ones who are working for it due to the fact that for any changes in the data input, the respective changes can be viewed. This paves the way to change the inputs often and often and compare their possible results associated with them. This kind of analysis gives us some better ideas of how the output changes with respective to a small change in the input. MATLAB is one such interactive programming language which makes all of the above discussed things possible. Through the graphical user interface tool we can input the data in real-time and see the outcome within a fraction of time. In other words we can input as many as we need and see the outcomes for all. This kind of analysis is of important in the research oriented projects. Also this is allows command by command execution instead of execution as a whole.
Coming to our proposed system, we are going to compare the performances of various detection methodologies and show the superiority of our system over others. Also we do analyse the system in AWGN as multipath Rayleigh channels. So we tried to plot our modulated signal as well and even multiple modulated signals and also attempted to plot the power spectral density too. The ROC plot is also shown for better understanding of our system in both AWGN and Rayleigh channel environments.

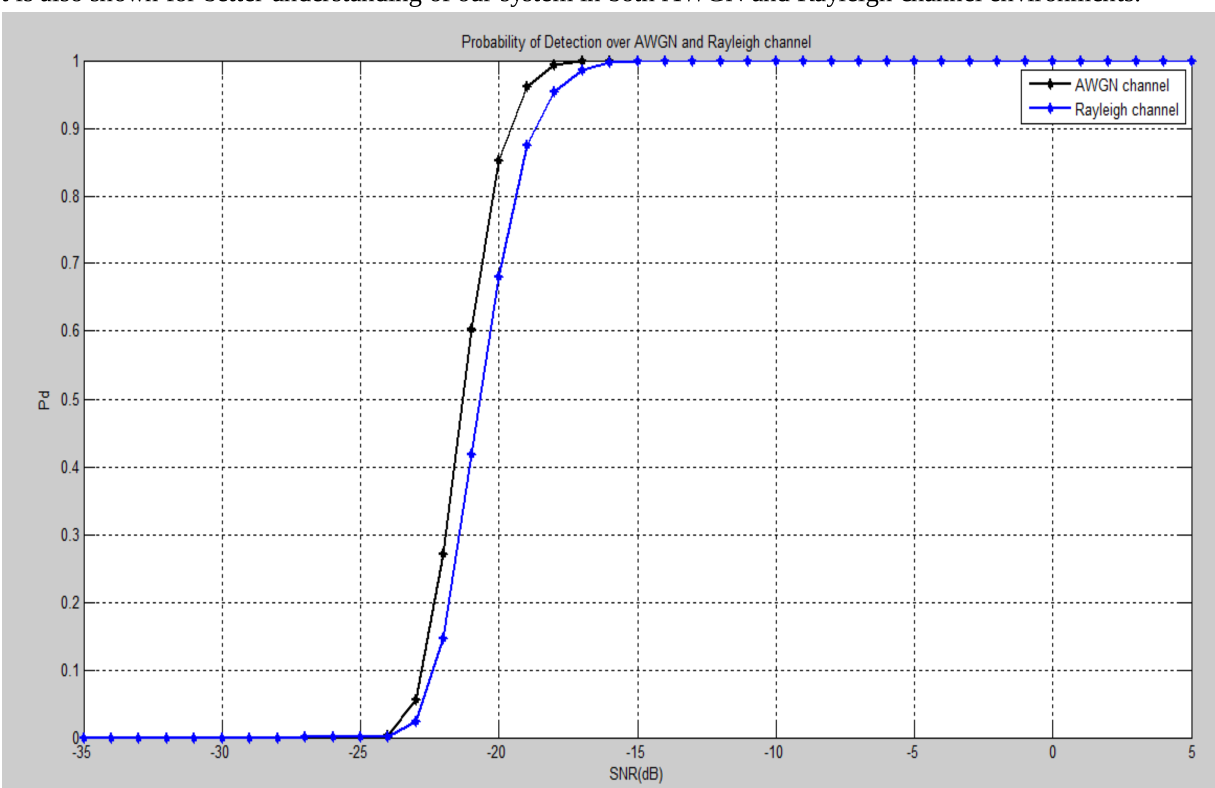

Fig 3 Probability of detection over AWGN and Rayleigh channels for M=7, N=512, PFA=0.01, W=20, Iterations= 500

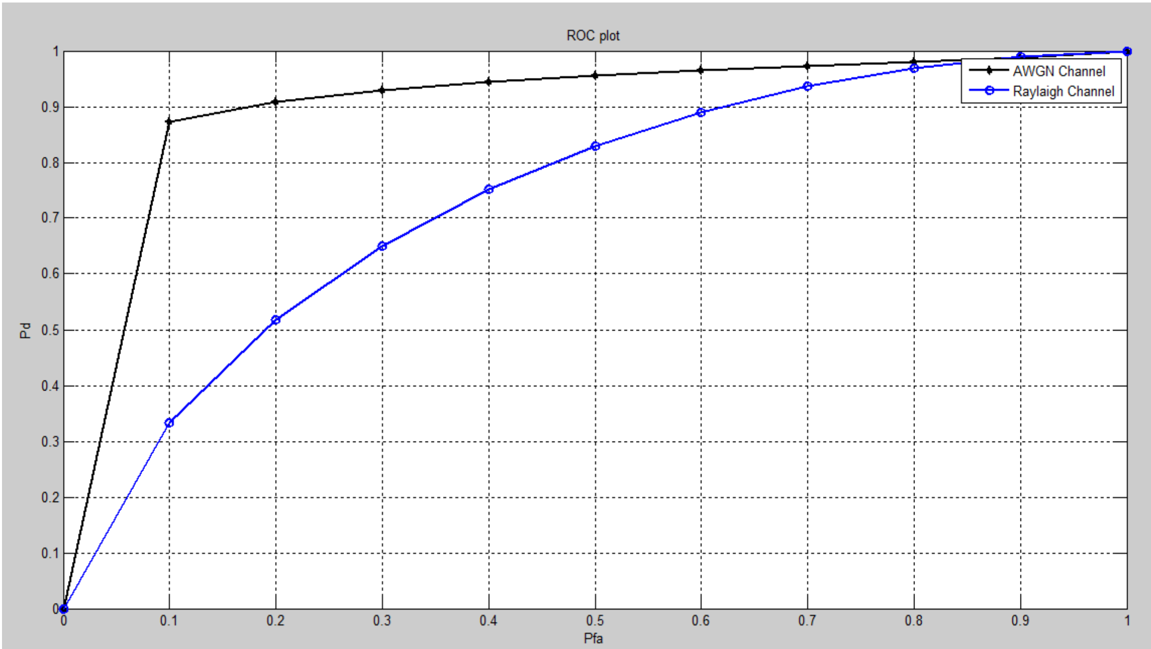

Fig 4 Roc plot for M=5, N=256, PFA=0:0.1:1, W=20, Iterations= 1000, SNR= -21db under both AWGN and Rayleigh channels

Comments**:** Our system performance is better felt by the receiver operating characteristic curve (ROC) which is a plot of PD versus Pf. At a fixed SNR s the ROC plot is depicted for both the AWGN as well as multipath Rayleigh Channels.

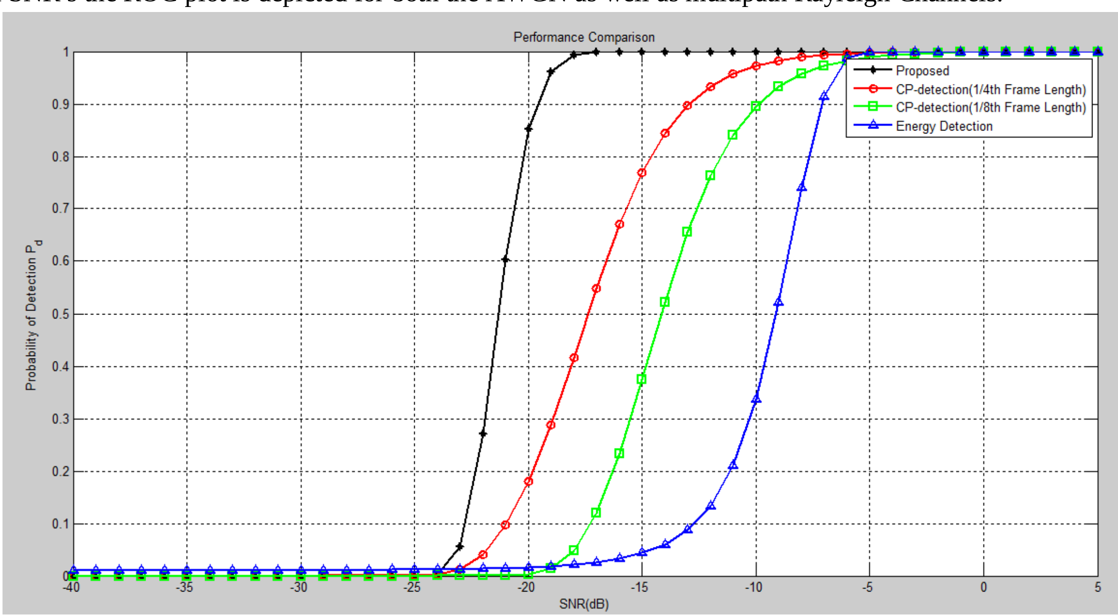

Fig 5 Performance Comparison of Different Methods for M=7, N=512, PFA=0.01, W=20, Iterations= 500

Comments: The important property of SC-FDMA is its quasi-periodicity**,** which is preserved even when affected by the multipath fading. Then in order to apply the Gaussian approximation we need to calculate mean and variance. However for such calculations we need to know about the keen details regarding the channel used. The superiority of our method can be better shown when compared with the energy and CP detection methods. Former one is older one which relies on detecting the signal energy. Latter one is calculating the auto-correlation of cyclic prefix and its replica. The superiority of our method can be viewed as, in order to obtain the some meaningful probability of detection, our method requires less SNR than that former method. The corresponding method with respect to the second method is in between 8 and 11 db. This is the scenario when the prefix length is in between ¼th and 1/8th

of frame length m. Effective improvements achieved if prefix length or number of users or number of FFT points in our method increases. But such things cannot be observed now only what we can do is to see changes by altering the length of the window. So when its length increases the Pd increases. If we discuss in terms of complexity, we can tell our method is on same order with the older ones

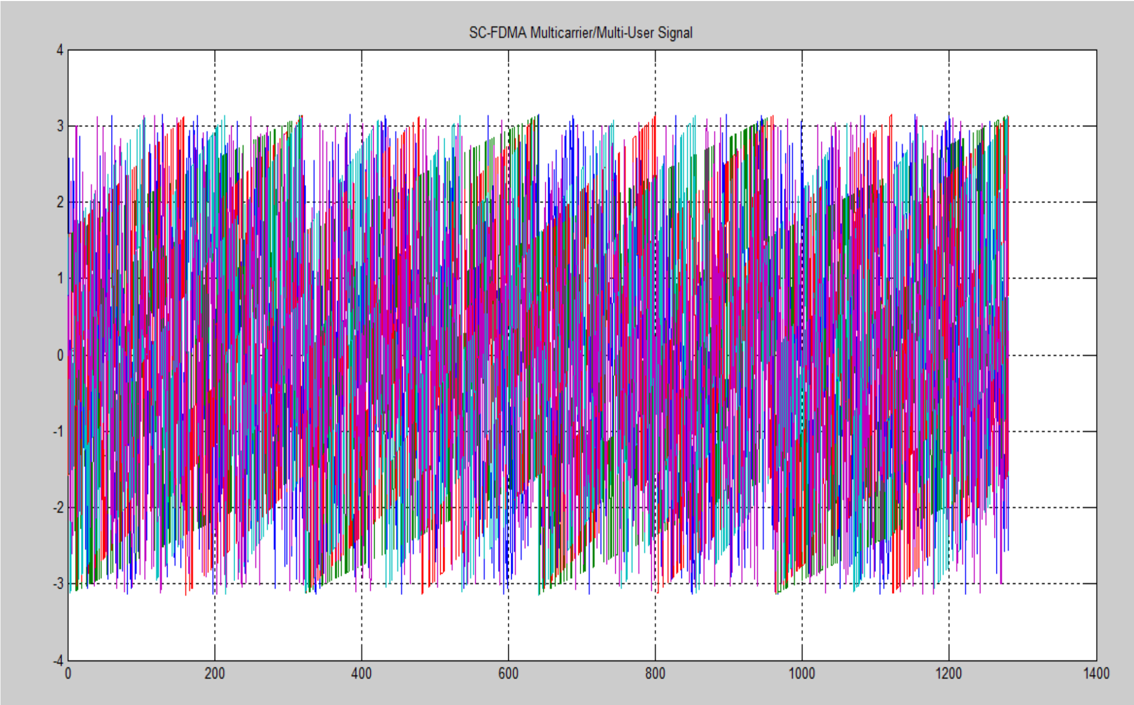

Fig 6 SC FDMA Multi-carrier/Multi-User Signal M=5, N=256, Mod type=QPSK, SNR= -20, Frames=1

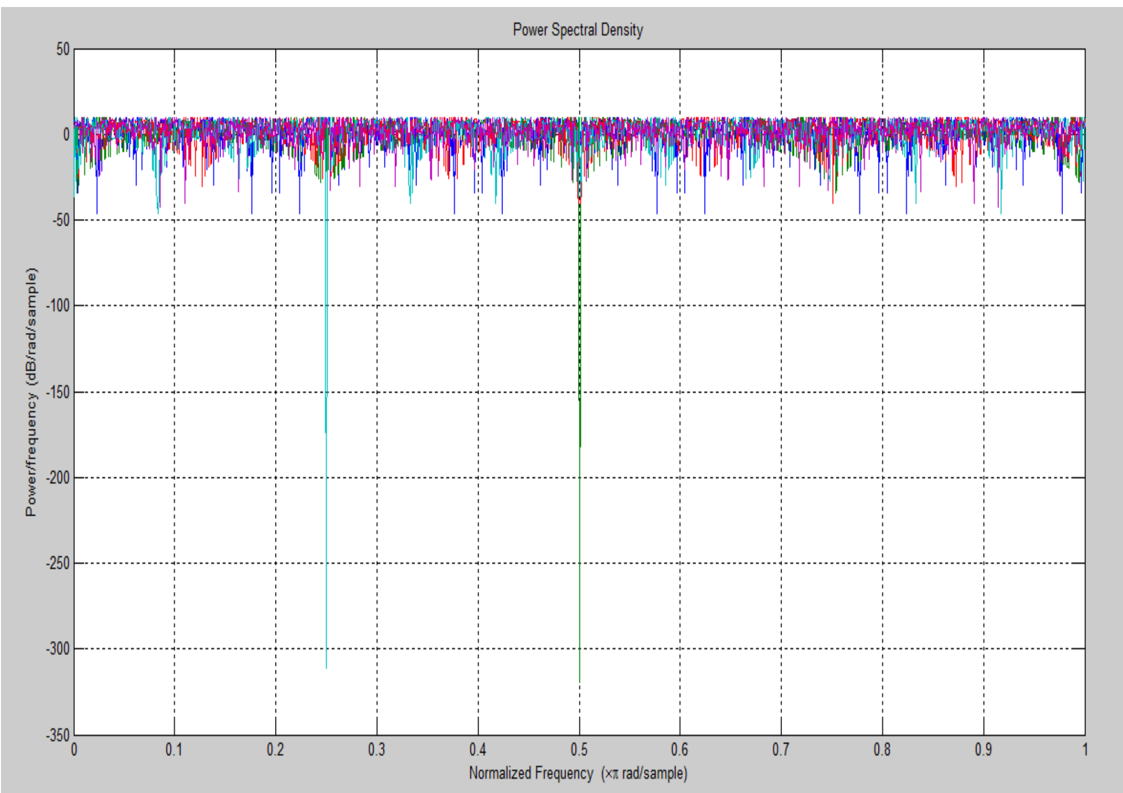

Fig 7 Power spectral density M=5, N=256, Mod type=QPSK, SNR=-20, Frames=

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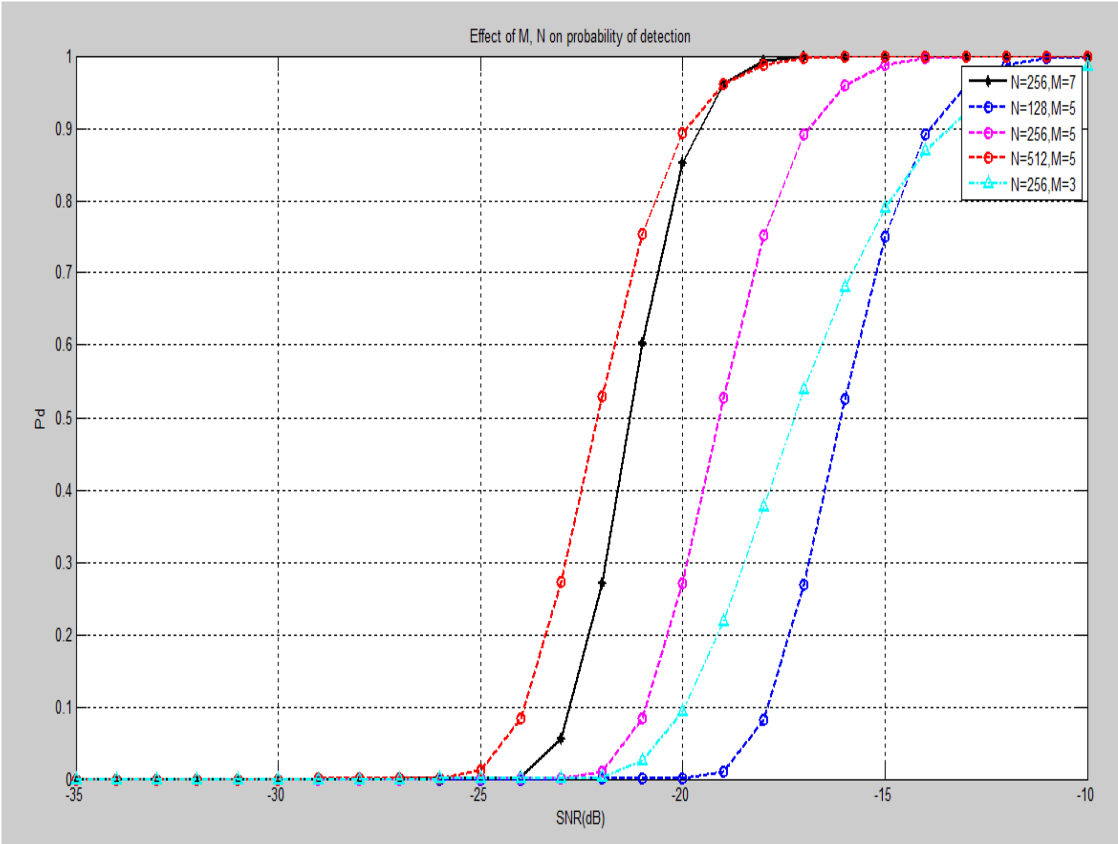

Fig 8 depicts the Pd vs. SNR for different values of N an M

Comments: Let us consider the case of all the users are transmitting and SOI is obtained by filtering. In doing so, the frequency components of the unwanted users are eliminated. As we discussed already an increase in M or N causes an increase in Pd as well as in the length of detection window. In particular we can tell as we increase the number of frames from 10 to 20, there will 2db gain at Pd of 0.8. We do use the pilot signals for estimating the channel as well as for the purpose of synchronization. In such cases, we can simulate the transmission of DM-RS. Thus the resulting sequence has fourth block dedicated to DM-RS. In this case degradation is about 1.5db.

V. CONCLUSIONS

This section summarizes the work done by us throughout the project phase. The intention behind our project is to develop detection scheme for SC-FDMA signals with the subcarrier assignment being continuous and using the cyclo-stationary features. The techniques so developed keeping in mind for both the conditions of presence and absence of Simulation results show how accurate we are. The performance is examined for AWGN by taking into account the effect of block length and multi-users criterion whereas for multipath fading for different data rates. We compared our method with the two other ones and showed how ours outperforms those two but at the expense of increased complexity.

VI. ACKNOWLEDGMENT

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REFERENCES

[1] K. B. Letaief and W. Zhang, Cooperative communications for cognitive radio networks, IEEE Trans. Wireless Commun, vol. 97, no. 5, pp. 878– 893, May 2009.

[2] D. Bhargavi and C. R. Murthy, Performance comparison of energy, matched-filter and cyclostationarity-based spectrum sensing, in Proc. IEEE 11th Int. Workshop SPAWC, Jun. 2010, pp. 1–5.

[3] M. M. Sebdani and M. J. Omidi, Detection of an LTE signal based on constant false alarm rate methods and constant amplitude zero autocorrelation sequence, in Proc. IEEE ICIAS, Jun. 2010, pp. 1–6.

[4] S. Chaudhari, V. Koivunen, and H. V. Poor, Autocorrelation-based decentralized sequential detection of OFDM signals in cognitive radios, IEEE Trans. Signal Process. vol. 57, no. 7, pp. 2690–2700, Jul. 2009.

[5] W. Zhang and Y. Sanada, Low-complexity cyclostationarity feature detection scheme of localized SC-FDMA uplink system for application to detect and avoid, in Proc. ISCIT, Oct. 2010, pp. 962–967.