ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 1, Issue 7, September 2012

A Survey on Cyclostationary Feature Spectrum Sensing Technique

Mr. Pradeep Kumar Verma[1], Prof. Rajeshwar Lal Dua[2]

[1]*M.Tech Scholar, Department of Electronics & Communication Engineering, Jaipur National University, Jaipur*

[2]*HOD, Electronics & Communication Engineering, Jaipur National University, Jaipur.*

Abstract*- Real time spectrum sensing with certain accuracy plays a key role in cognitive radio. In this paper Cyclostationary feature spectrum sensing technique is discussed. Cyclostationary feature can be used for spectrum sensing in a very low SNR environment (less than -20 dB). The sensing algorithms are based on measurement of cyclic properties of the received signals. Usually, cyclostationary feature detection requires high computation complexity.

***Keywords*- Cognitive Radio (CR), Cyclosttionary Feature detection, Signal to Noise Ratio (SNR), Power Spectral Density (PSD), Wide-sense Stationary (WSS), Energy Detection (ED).**

I. INTRODUCTION

Today, by unprecedented growth of wireless applications, the problem of spectrum scarce is becoming apparent. Most of the spectrum has been allocated to specific users, while other spectrum bands that haven't been assigned are overcrowded because of overuse. However, most of the allocated spectrum is idled in some times and locations. The Federal Communication Commission (FCC) research report [1] reveals that, seventy percent of the allocated spectrum is underutilized. So we need a technique to deal with the problem of spectrum underutilization, which makes the birth of cognitive radio. Cognitive radio [2][3]can sense external radio environment and learn from past experiences. It can also access to unused spectrum band dynamically without affecting the licensed users, in such a way to improve the spectrum efficiency. Sensing external radio environment quickly and accurately plays a key role in cognitive radio. Energy detection [4], pilot detection [4], and cyclostationary feature detection [4] are three commonly used spectrum sensing methods. Energy detection is easy to

$$R_x(t,\tau) = \sum_{m=-\infty}^{+\infty} R_x^{m/T_0}(\tau) e^{j2\pi mt/T_0} \quad (2)$$

implement, but its performance degrades greatly under low signal-to- noise ratio (SNR) or with noise uncertainty. Pilot detection can detect signals with low SNR, but it needs the licensed user's prior knowledge and perfect synchronization, which is hard to realize in reality.

Cyclostationary feature detection is a method for detecting primary user transmissions by exploiting the cyclostationarity features of the received signals. Cyclostationary features are caused by the periodicity in the signal or in its statistics like mean and autocorrelation or they can be intentionally induced to assist spectrum sensing. Instead of power spectral density (PSD), cyclic correlation function is used for detecting signals present in a given spectrum. The cyclostationarity based detection algorithms can differentiate noise from primary users signals. This is a result of the fact that noise is wide-sense stationary (WSS) with no correlation while modulated signals are cyclostationary with spectral correlation due to the redundancy of signal periodicities. Furthermore, cyclostationarity can be used for distinguishing among different types of transmissions and primary users [5].

II. PRINCIPLE OF CYCLOSTATIONARITY

Modulated signals are in general coupled with cosine carrier, repeating spreading, over-sampling etc., resulting in built-in periodicity. When the signal's mean and auto- correlation exhibit periodicity, i.e., $m_x(t+T) = m_x(t)$, $R_x(t+T,u+T)=R_x(t,u)$, we call this signal a second- order cyclic statistics process[8]. The auto-correlation of signal ( )*xt* is defined as

$$R_x(t,\tau) = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=N}^{N} x(t+\tau/2+nT_0)x^*(t-\tau/2+nT_0) \quad (1)$$

Since $R_x(t,\tau)$ is periodic with period T_0, it can be expressed as a Fourier series representation

$$R_x^{\alpha}(\tau) = \frac{1}{T_0}\int_{-\infty}^{\infty} R_x(t,\tau) e^{-j2\pi\alpha t} dt \quad (3)$$

Where α is the second-order cycle frequency equals to m/T_0, $R_x^{\alpha}(\tau)$ is referred to as the cyclic autocorrelation function. The spectrum α coherence function (SCF) can be obtained as

$$S_x^{\alpha}(f) = \int_{-\infty}^{\infty} R_x^{\alpha}(\tau) e^{-j2\pi f\tau} d\tau = \frac{1}{T} X(f+\alpha/2) X^{*}(f-\alpha/2) \quad (4)$$

Where *X(f)* is the Fourier Transform of the signal *x(t)*. From (4) we can find that $S_x^{\alpha}(f)$ is the correlation of the signal spectrum.

III. CYCLOSTATIONARY FEATURE DETECTION

It exploits the periodicity in the received primary signal to identify the presence of primary users (PU). The periodicity is commonly embedded in sinusoidal carriers, pulse trains, spreading code, hopping sequences or cyclic prefixes of the primary signals. Due to the periodicity, these cyclostationary signals exhibit the features of periodic statistics and spectral correlation, which is not found in stationary noise and interference [6].

Thus, cyclostationary feature detection is robust to noise uncertainties and performs better than energy detection in low SNR regions. Although it requires a priori knowledge of the signal characteristics, cyclostationary feature detection is capable of distinguishing the CR transmissions from various types of PU signals. This eliminates the synchronization requirement of energy detection in cooperative sensing. Moreover, CR users may not be required to keep silent during cooperative sensing and thus improving the overall CR throughput. This method has its own shortcomings owing to its high computational complexity and long sensing time. Due to these issues, this detection method is less common than energy detection in cooperative sensing [7].

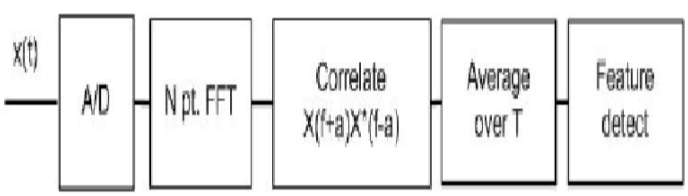

Figure 1: Block diagram of Cyclostationary feature detection.

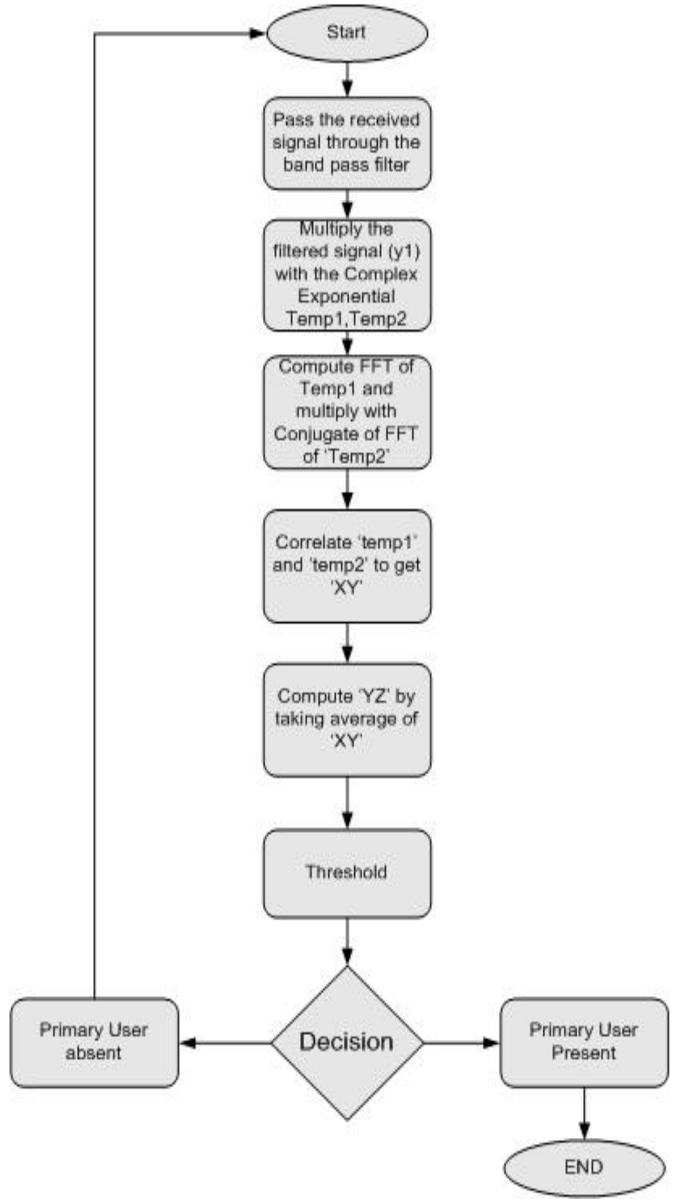

Figure 2: Flow diagram of Cyclostationary feature Detection.

IV. RESULTS AND ANALYSIS

An extensive set of simulations have been conducted using the system model as described in the previous section. The emphasis is to analyze the comparative performance of three spectrum sensing techniques. The performance metrics used for comparison include the "probability of primary user detection" and "probability of false detection". The number of channels and the number primary users considered in this analysis is twenty five and respectively. The SNR of the channels is considered to be precisely same and the channel model is A W G N with zero mean. The results are shown in Figure-3 and Figure-4.

ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 1, Issue 7, September 2012

1. Probability of Primary Detection

Figure-3 depicts the "probability of primary user detection" as a function of SN R for the three cases: (i) energy detection, (ii) matched filter detection and (iii) cyclo-tationary feature detection. It is observed that for energy detection and matched filter detection, much higher SNR is required to obtain a performance comparable to cyclostationary feature detection. For energy detection, about 16 dB s higher SNR is needed to achieve 100% probability of detection whereas for matched filter detection, about 24 dB s higher SNR is required. For cyclostationary feature detection, 100% probability of detection is attained at -8 dB s. Cyclostationary feature detection performs well for very low SNR, however the major disadvantage is that it requires large observation time for occupancy detection. Matched filter detection performs well as compared to energy detection but restriction lies in prior knowledge of user signaling. Further, cyclostationary feature detection algorithm is complex as compared to other detection techniques.

2. Probability of False Detection

Figure-4 illustrates the "probability of false detection" for three transmitter detection based spectrum sensing techniques versus SNR. It is observed that "probability of false detection" of cyclostationary feature detection is much smaller as compared to other two techniques. In fact, it is zero for the range of SNR considered in this study i.e., -30 dB to + 30 dB s. It is further seen that the "probability of false detection" for energy detection technique is inversely proportional to the SNR. At low SNR we have higher probability of false detection and at high SNR we have lower probability o f false detection, because energy detection cannot isolate between signal and noise. T he probability of false detection for energy detection and matched filter detection approaches zero at about +14 dBs and +8 dBs respectively.

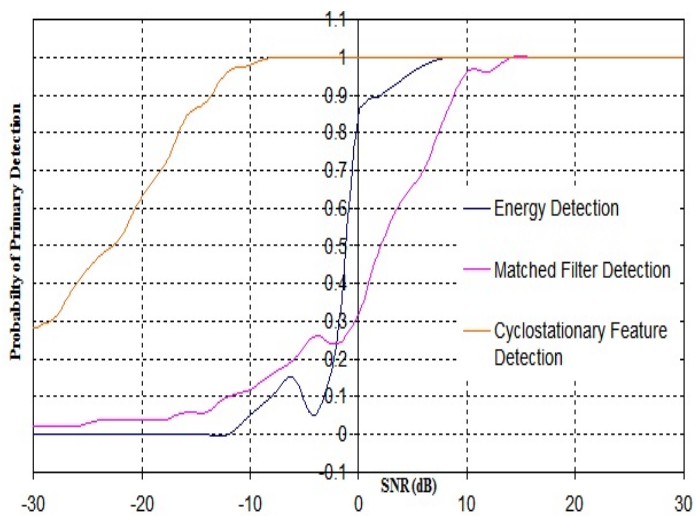

Figure 3: Probability of Primary Detection.

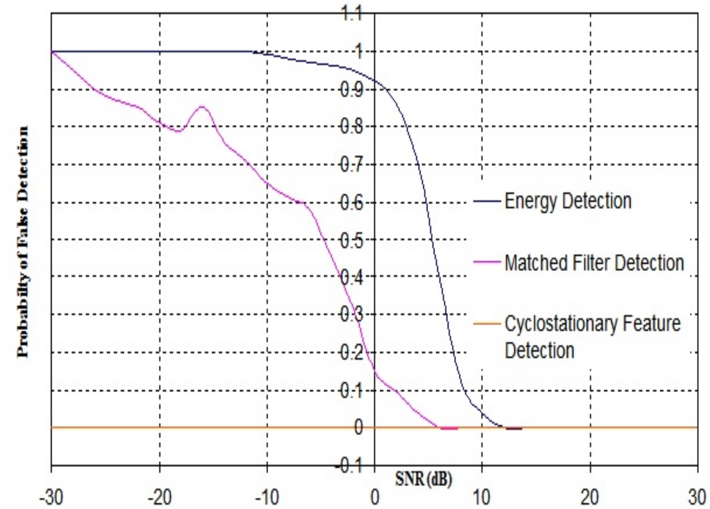

Figure 4: Probability of False Detection.

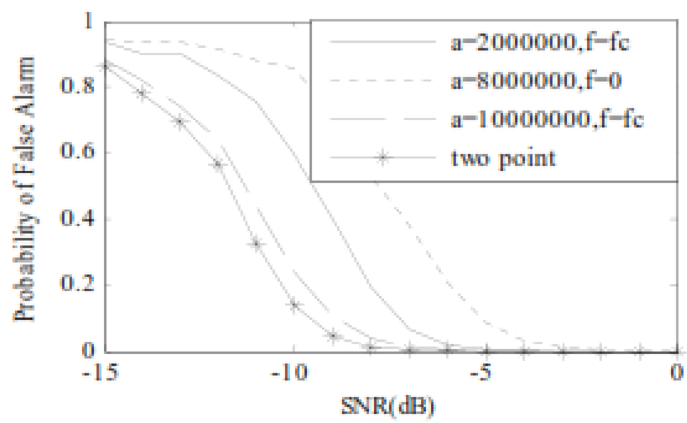

Figure 5: Performance of Cyclostationary feature detection under P_d=0.95.

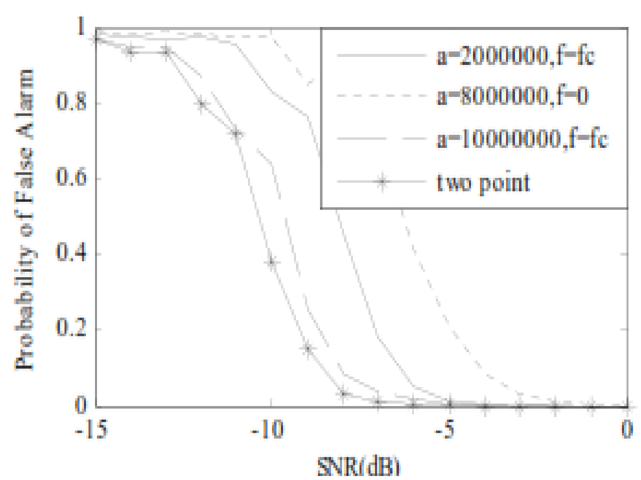

Figure 6: Performance of Cyclostationary feature detection under P_d=0.99.

ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 1, Issue 7, September 2012

V. CONCLUSION

To efficiently utilize the wireless spectrum cognitive radios were introduced which opportunistically utilize the holes present in the spectrum. The most essential aspect of a cognitive radio system is spectrum sensing and various sensing techniques which it uses to sense the spectrum. In this paper the main focus was on Energy Detection, Matched Filter Detection and Cyclostationary feature Detection spectrum sensing techniques. The advantage of Energy detection is that, it does not require any prior knowledge about primary users. It does not perform well at low SNR values, it requires a minimum SNR for its working. The result in the paper shows that Energy detection starts working at -7 dB s of SNR. Matched filter detection is better than energy detection as it starts working at low SNR of -30 dB s. Cyclostationary feature detection is better than both the previous detection techniques since it produces better results at lowest SNR, i.e. for values below -30 dB s. the results shows that the performance of energy detection gets better with increasing SNR as the "probability of primary detection" increases from zero at -14 dB s to 100% at +8 dB s and correspondingly the "probability of false detection" improves from 100% to zero. Similar type of performance is achieved using matched filter detection as "probability of primary detection" and the "probability of false detection" shows improvement in SNR as it varies from -30 dB s to +8 dB s. the cyclostationary feature detection outclasses the other two sensing techniques as 100% "probability of primary detection" and zero "probability of false detection" is achieved at -8 dB s, but the processing time of cyclostationary feature detection is greater than the energy detection and matched filter detection techniques.

The second-order cyclic features built-in in modulated signals is used to detect the signals. Due to high complexity of cyclostationary feature detection, we choose to detect specific frequencies and cyclic frequencies based on the signal's feature to degrade complexity greatly. We compare the detection performance of different points to find the best detection points through simulation analysis and propose to combination detection method using multiple detection points to get better performance. Results validate the effectiveness of the proposed detection method.

References

[1] Federal Communications Commission. Spectrum Policy Task Force Report. Washington: *ET Docket*, 2002:2-135.

[2] J Mitola, G.Q. Maguire, " Cognitive Radio:Making Software Rradios More Personal," *IEEE Personal Communications Magazine*, 6(4), pp.13-18, 1999.

[3] I .Akyildiz, Q Lee, M C.Vuran, "Next Generation/dynamic Spectrum Access/cognitive Radio Wireless Network: A Survey," *Computer Networks*, 50(13), pp.2127-2159, 2006.

[4] X Zhou, H Zhang, The Priciple and Application of Cognitive Radio. Beijing, *Beijing University of Posts and Telecommunications Press*, pp.16-25, 2007.

[5] S. Kapoor and G. Singh, ―*Non-Cooperative Spectrum Sensing: A Hybrid Model Approach*‖, International Conference on Devices and Communications, No. 3 pp. 115, 2011.

[6] A. Tkachenko, D. Cabric, and R. W. Brodersen, (2007), "Cyclostationary feature detector experiments using reconfigurable BEE2," in Proc. IEEE Int. Symposium on New Frontiers in Dynamic Spectrum Access Networks, Dublin, Ireland, Apr, pp: 216-219.

[7] R. Tandra and A. Sahai (2007), "SNR walls for feature detectors", in Proc. IEEE Int. Symposium on New Frontiers in Dynamic Spectrum Access Networks, Dublin, Ireland, Apr, pp: 559–570.

Authors

Pradeep Kumar Verma – Student of M. Tech (Communication and signal processing) final semester at Jaipur National University, Jaipur. Completed B. Tech from Northern India Engineering College, Lucknow from Uttar Pradesh Technical University in Electronics and Communications Engineering in 2009. Worked as Site Engineer for 9 months in Telecom Industry. He has keen interest in subjects like signal and systems, digital communications, information theory and coding and wireless communications.

Prof. Rajeshwar Lal Dua a Fellow Life Member of IETE and also a Life member of I.V.S & I.P.A, former "Scientist F" of the Central Electronics Engineering Research Institute (CEERI), Pilani has been one of the most well-known scientists in India in the field of Vacuum Electronic Devices for over three and half decades. His professional achievements span a wide area of vacuum microwave devices ranging from crossed-field and linear- eam devices to present-day gyrotrons. He was awarded a degree of M.Sc (Physics) and M.Sc Tech (Electronics)from BITS Pilani. He started his professional carrier in1966 at Central Electronics Engineering Research Institute (CEERI), Pilani. During this period he designed and developed a specific high power Magnetron for defence and batch produced about 100 tubes for their use. Trained the Engineers of Industries with know how transfer for further production of the same. In 1979 he visited department of Electrical and Electronics Engineering at the University of Sheffield (UK) in the capacity of independent research worker, and Engineering Department of Cambridge University Cambridge (UK) as a visiting scientist. After having an experience of about 38 years in area of research and development in Microwave field with several papers and a patent to his credit. In 2003 retired as scientist from CEERI, PILANI & shifted to Jaipur and joined the profession of teaching. From last eight years he is working as professor and head of electronics department in various engineering colleges. At present he is working as head and Professor in the department of Electronics and communication engineering at JNU, Jaipur. He has guided several thesis of M.tech .of many Universities.