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# Analysis and Comparison of Different Spectrum Sensing Technique for WLAN

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**ABSTRACT**

This Paper explores basic two systems of spectrum sensing: Cooperative System & Non-Cooperative System. Non-Cooperative System includes Energy detector, Match Filter and cyclostationary with a performance analysis of transmitter based detection. It also includes analysis of Match Filter and Cyclostationary under low and high SNR, validating the result and applied the technique for Wireless local Area Network (WLAN). To identify the no. of detected signal, chi-square equation has been solved and finds the threshold. It has been observed during analysis that energy rises at high SNR under AWGN and under high SNR no. of detected signal decreases gradually when the no. of sample increases. When no. of sample increases then the no. of detected signal increases. The results of the detection techniques are reliable in comparison. Energy detection provides good result under high SNR values. All of the simulation work is done in MATLAB software and finalized the best detection technique for spectrum sensing.

***KEYWORDS:*** *Cognitive radio, Non-cooperative system, WLAN, WIMAX, AWGN*

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## 1. INTRODUCTION

The Cognitive Radio is a technology which efficiently utilizes the licensed spectrum without causing any harm to the licensed users. It searches the licensed frequency bands for unused spectrum, and uses them efficiently. The unused licensed spectrum is also known as 'white spaces'. CR devices monitor a radio spectrum and modify their operational parameters such as frequency, different modulation schemes, and transmitting power, in order utilize available natural resources. A CR can increase spectrum efficiency leading to higher bandwidth and reduce the burdens of centralized spectrum management by a particular spectrum distribution authority.

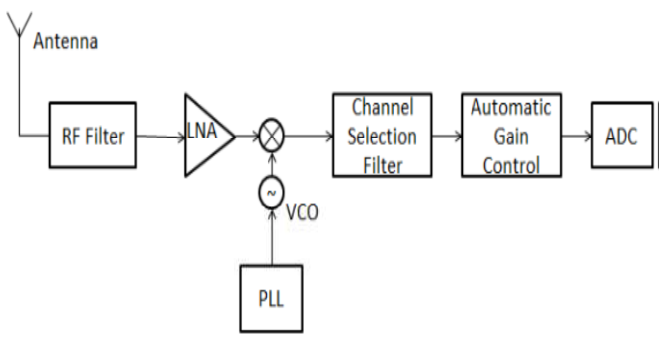


**Fig:-1 Physical Architecture of Cognitive Radio**

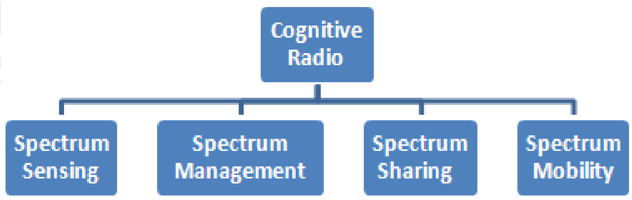


**Fig:-2 Functional Block diagram of CR**

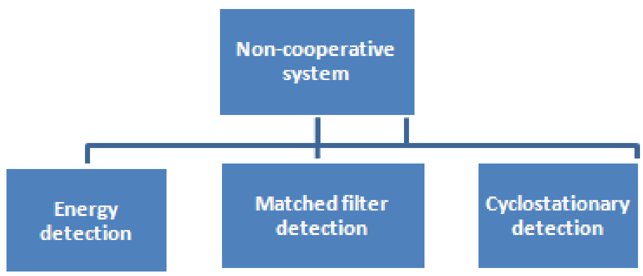


**Fig:-3 Types of Non-Cooperative System**

## 2. LITERATURE REVIEW

Fazlullah et al (2018) [9] suggested the fuzzy logic cooperative spectrum sensing, asynchronous cooperative spectrum sensing, cooperative spectrum sensing based on network coding, cooperative spectrum sensing with relay diversity, and distributed cooperative spectrum sensing based network coding. The CR opportunistically access vacant spectrum bands in a licensed spectrum. When the current band/channel becomes unavailable, the device can switch to another available channel. However, for the realization of the cognitive radio networks, spectrum sensing is the ground work and also regulatory bodies need to adopt flexible and non-fixed policies & techniques. In this paper, we analyze different spectrum sensing techniques to detect the presence of the Primary User.

**You En Lin et al (2017) [8]** said that spectrum sensing based entirely on the two metrics is unable to maximize spectrum utilization for dynamic spectrum access. He also show that, to meet the requirement of the probability of missed detection, conventional spectrum sensing techniques can unnecessarily increase the probability of false alarm in scenarios with good spectrum reuse opportunity, thus lowering the ability to leverage spectrum holes. To address this problem, he define the probability of interference and propose a new metric for spectrum sensing to consider both the probabilities of interference and missed detection.

Spectrum sensing is an important step toward enabling dynamic spectrum access in cognitive radio networks. To ensure that primary users are properly protected while maximizing the performance of secondary users, most related work considers the metrics of probabilities of missed detection and false alarm for determining optimal spectrum sensing parameters.

**Lei yang et al (2016) [6]** introduces a new technique cyclo-energy detector by combining two technique energy detector and cyclostationary. Cyclo-energy detector is proposed for the spectrum sensing problem based on the cyclostationary signal analysis. The proposed detector can determine the existence of primary user by estimating the primary users received power according to the cyclostationary features of the secondary user. By using this detector, the secondary user does not need to stop Transmitting signals when sensing the frequency spectrum.

## 3. PROBLEM FORMULATION

The matched filter correlates the known signal x(n) with the unknown signal s(n) and decision is made through T(x). Test statistic is normally distributed under both hypotheses,

$$T(x) = \sum_{n=1}^{N} x(n) s*(n) \quad \text{(i)}$$

$$T(x) \sim \begin{cases} N(0, NP_S\ \sigma_n^2)\ X_0 \\ N(NP_S, NP_S\,\sigma_n^2)\ X_1 \end{cases} \quad \text{(ii)}$$

The probability of false alarm & detection are

$$P_f = Q\,\frac{\gamma}{\sigma_n \sqrt{NP_S}} \quad \text{(iii)}$$

$$P_d = Q\,\frac{\gamma - NP_S}{\sigma_n \sqrt{NP_S}} \quad \text{(iv)}$$

Where N is the no of sample, $\sigma_n^2$ is the noise variance & $P_s$ is the average primary signal power. Where Y(n), X(n) are the received signals at CR nodes, transmitted signals at primary nodes and white noise samples respectively.

$$D(Y) = \begin{cases} \frac{1}{N}\sum_{n=0}^{N-1} Y(n)X(n), > \lambda\, X_1 \\ \qquad\qquad\qquad < \lambda\, X_0 \end{cases} \quad \text{(v)}$$

Where D(Y) is the decision variable and λ is the decision threshold, N is the number of samples.

$$D\left(\frac{Y}{X_0}\right) \sim N(0, P\sigma_n^2/N) \quad \text{(vi)}$$

Where P is the average signal power and $\sigma_n^2$ is the noise variance

$$D\left(\frac{Y}{X_1}\right) \sim N(0, P\sigma_n^2/N) \quad \text{(vii)}$$

$P_d$ is the probability of detection & $P_f$ is the probability of false alarm. $P_{md}$ is the probability of the missed detection .The following probability expressions are

$$P_f = P_r\left(D\left(\frac{Y}{X_0}\right)\right) = Q\left(\frac{\lambda}{\sqrt{P\sigma_n^2/N}}\right) \quad \text{(viii)}$$

$$P_d = 1 - P_{md} = Q\left(\frac{\lambda - P}{\sqrt{P\sigma_n^2/N}}\right) \quad \text{(ix)}$$

Where Q( ) is the standard Gaussian complementary cumulative distribution function.

$$Q^{-1}(P_f) = \frac{\lambda}{\sqrt{P\sigma_n^2/N}} \quad \text{(x)}$$

$$Q^{-1}(P_d) = \frac{\lambda - P}{\sqrt{P\sigma_n^2/N}} \quad \text{(xi)}$$

$Q^{-1}()$ is the inverse standard gaussian complementary CDF, SNR=$P/\sigma_n^2$

$$Q^{-1}(P_f) - Q^{-1}(P_d) = \frac{P}{\sqrt{P\sigma_n^2/N}} \quad \text{(xii)}$$

$$N = [Q^{-1}(P_f) - Q^{-1}(P_d)]^2\,(SNR)^{-1} \quad \text{(xiii)}$$

## 4. GEOMETRICAL MODEL OF MATCHED FILTER DETECTOR

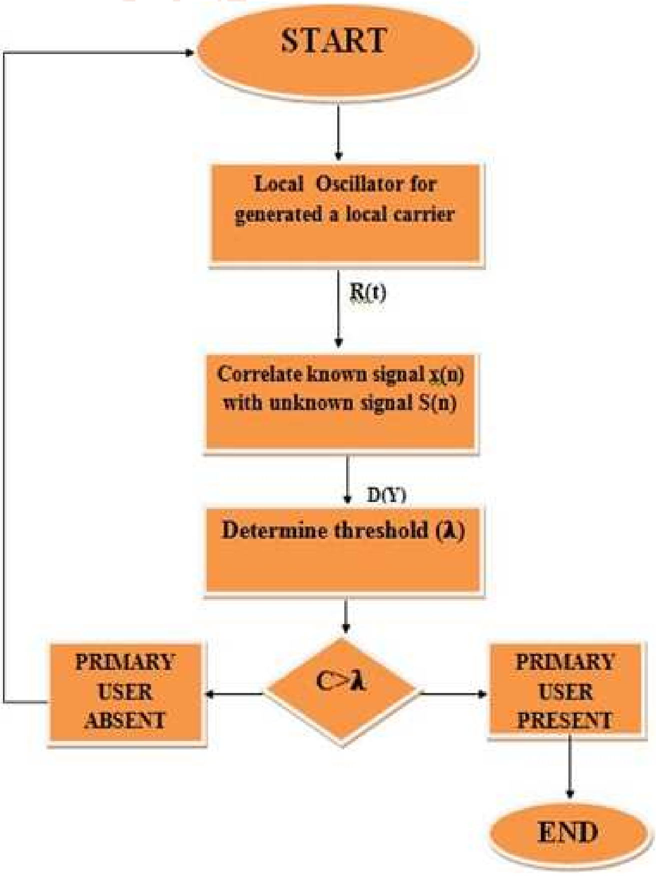


**Fig:-4 Flow chart of Matched filter**

## 5. RESULT

### Result for Power Spectral Density of Energy Detector

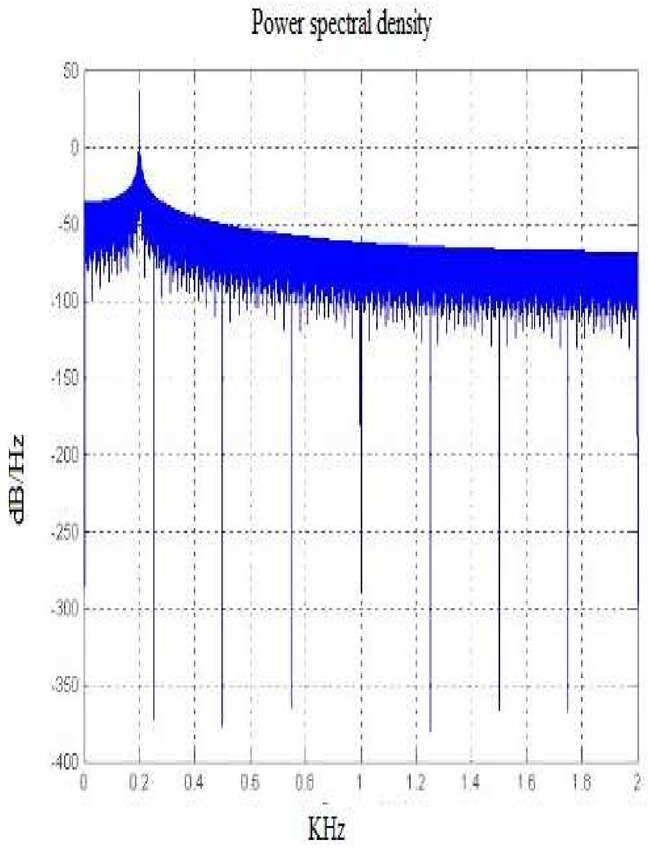


**Fig.5 30 dB SNR at 200 Hz When PU is Present**

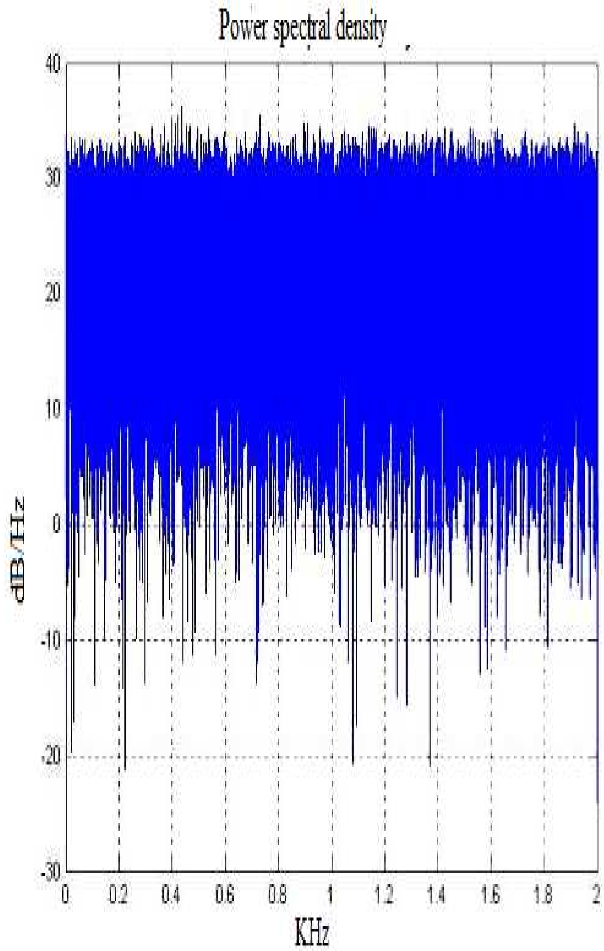


**Fig. 6 -30 dB SNR at 200 Hz When PU is Present**

### Result for Power Spectral Density of Matched Filter Detector

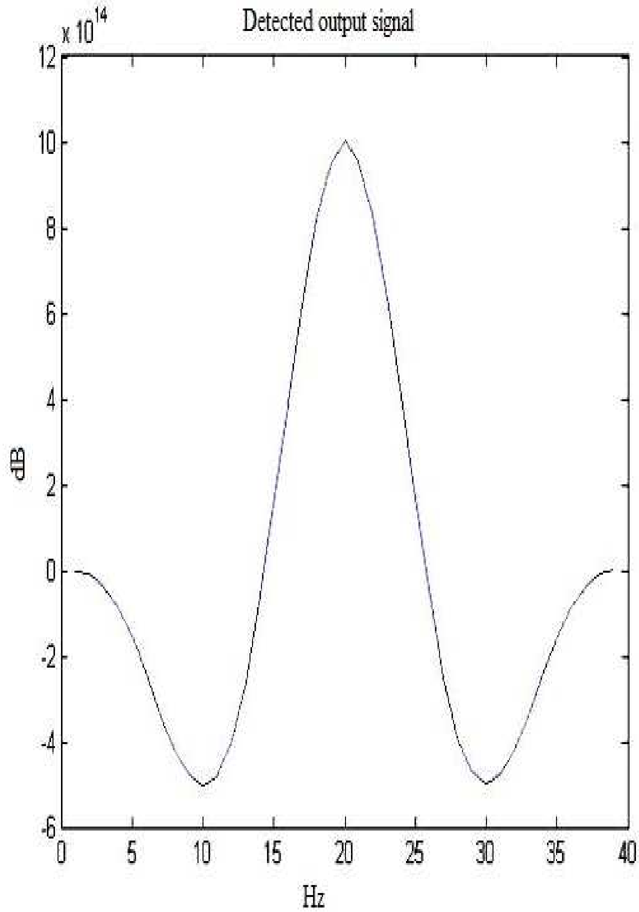


**Fig.7 Correlation of Received Signal**

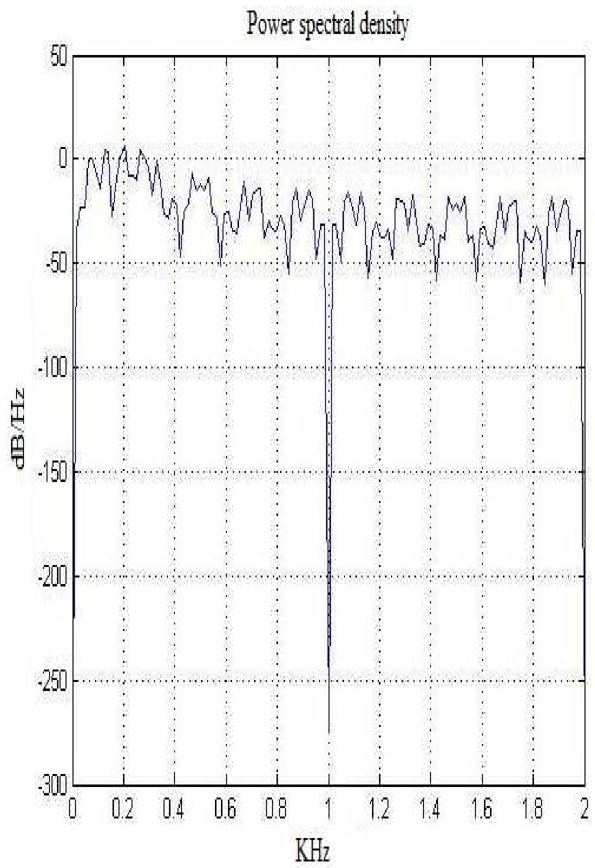


**Fig. 8 Matched Filter Output at 30 dB SNR When PU is Present**

**Result of Cyclostationary Detector**

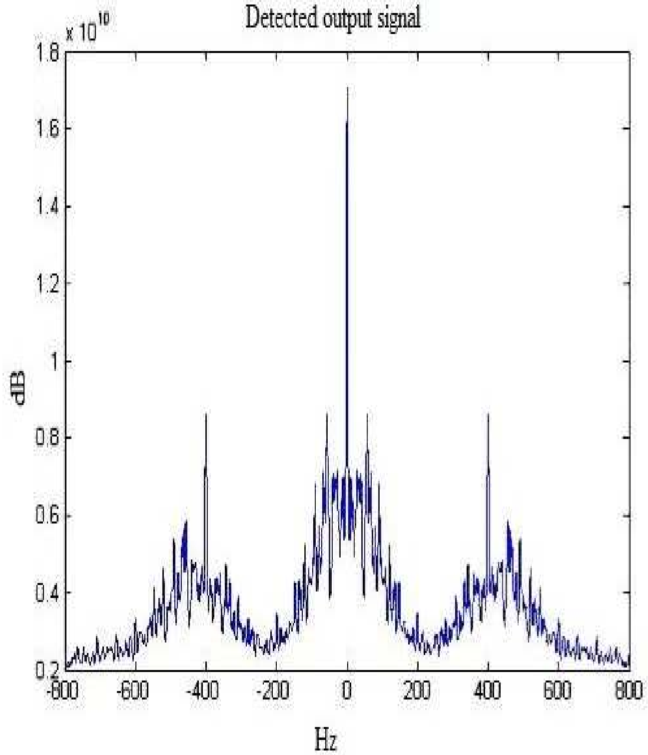


**Fig. 9 Cyclostationary Detector at 30 Db SNR When PU is Present at 200 Hz**

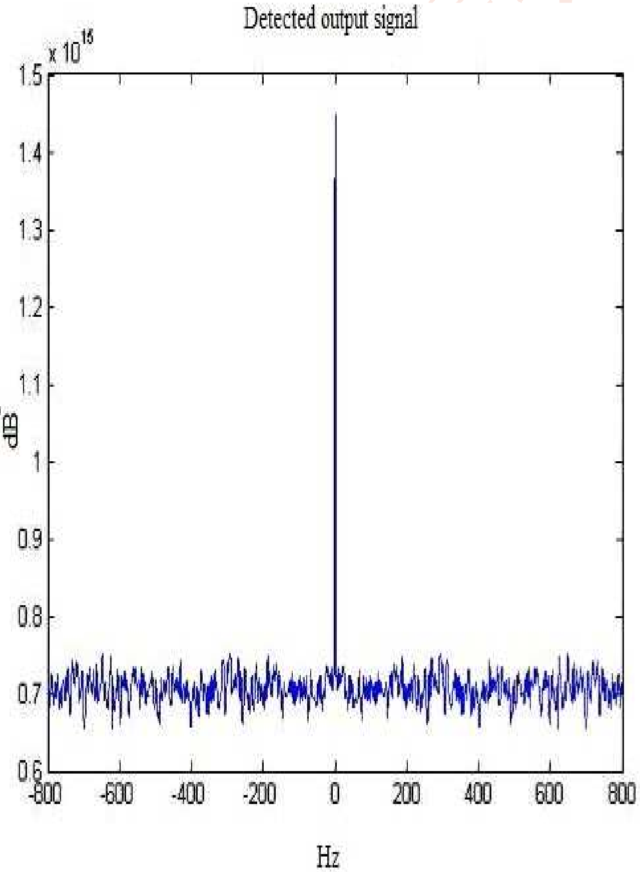


**Fig.10 -30 dB SNR at 200 Hz**

## 6. CONCLUSION

Energy detector detects that primary user is present under low SNR conditions and the main drawback of energy detection is that it can't distinguish between noise and energy of the signal.

Through energy detection technique it has found that when sample is low the energy achieved at low SNR is low while at high SNR energy is higher.

The sample size is been increased the variation of signal is more, the energy graph becomes steeper and the energy becomes lower for both high & low SNR.

Under Matched filter detection the possibility of detection is high in case of high SNR but it been reduce when we increase the sample size.

Cyclostationary feature detection gives best results but take long computation time compared to other techniques.

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