# ENERGY DETECTION BASED SPECTRUM SENSING FOR COGNITIVE RADIO

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***Abstract* — Cognitive Radio is an emerging technology which avoids the congestion in wireless communication by exploiting unused radio spectrum . The Spectrum sensing plays a fundamental requirement of CR which finds an unused free spectrum and detects the licensed user transmissions.energy detection constitutes a preferred approach for cognitive rdio spectrum sensing due to its simple applicability. In this paper Wiener khinchin theorem ,QAM techniques are used for the energy detection**

**Keywords—Cognitive Radio(CR),Spectrum sensing, Energy detection , QAM , Wiener khintchin theorem, Orthogonal Frequency Division Multiplexing (OFDM).**

## I. INTRODUCTION

CR is an persuasive resolution to the spectral congestion crisis by establishing the opportunistic exploitation of unused frequency bands that are not significantly engaged through a licensed users. They cannot be utilized by users other than the license CR users at the moment. OFDM is one of the most extensively used technologies in recent wireless communication systems which has the latent of satisfying the necessities of cognitive radios intrinsically or with minor changes. With it interoperability among the different protocols, it becomes easier.

Cognitive Radio networks are wisely detects the available primary spectrum band to eliminates the absence of licensed primary users. The methods of spectrum sensing provides more spectrum utilization chances to the CR users with no intrusive with the process of the licensed network.

Three major methods used in spectrum sensing are

1)Energy detection

2)Cyclostationary

3)Matched filter

Among the above 3 methods Energy detection is a basic and popular method. Since Cyclostationary or Feature detection based spectrum sensing uses the exclusive prototype of the signal to sense its existence. But it is more complicated to implement and sensitive to the impairments between the cyclic frequency, carrier frequency and sampling frequency.

Matched filter Performs coherent detection. But it acquires optimal solution to the signal detection but it requires priori knowledge on the received signal.

## II. ENERGY DETECTION IN SPECTRUM SENSING

This is a non-coherent detection that utilizes the received signal energy to resolve the occurrence of a primary signals. In general Cognitive Radio handlers have no estimations to be provide with any preceding knowledge about the primary signals that can be present with in a particular frequency band. whenever the secondary user cannot get together any plenty knowledge, then the energy detection can be used due to its capability to perform without the signal structure to be detected.

Energy detection can be done by comparing energy of a received signal in a certain frequency band to properly set decision threshold. If the signal energy lies greater with the decision threshold, then the frequency channel is stated to be busy. Otherwise the channel is supposed to be idle (free) and could be accessed by CR users. Energy detection could be used in both Time domain and Frequency domain operations.

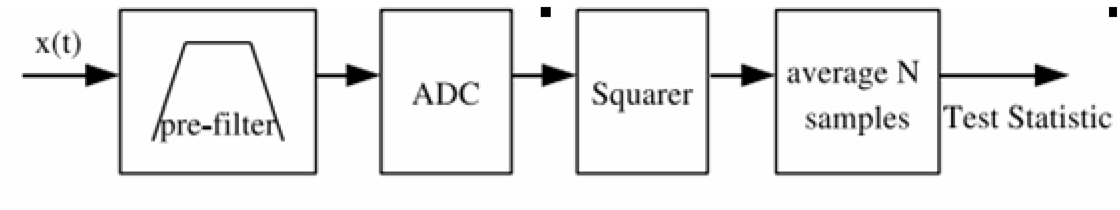


Fig.1. Time domain representation of energy detection

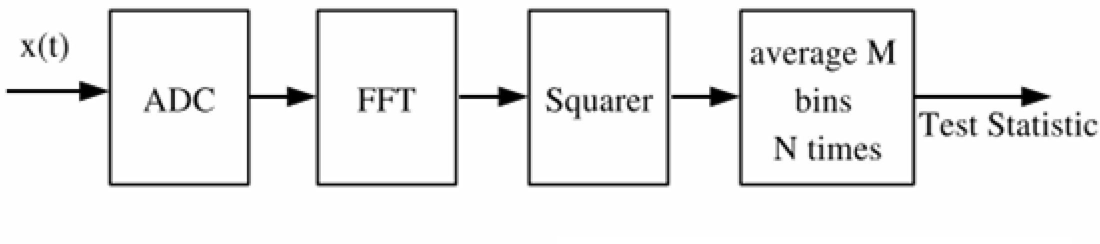


Fig.2. Frequency domain representation of energy detection

In this energy detection, energy of an averaged signal is subjected to two hypothetical test functions.

1) H0 (PU is absent)
2) HI (PU is in operation)

Under H0

x[n] = w[n]; (occurence of noise only )

Under H1

x[n] = s[n] + w[n]; (occurence of signal with noise)

Here, n = 0, 1, 2, ...., N-1, N represents the index of sample, w[n] specifies the noise and s[n] is the primary signal required to detect. H0 is the hypothesis which means that the received signal consists of the noise only. In case of H0 is true then the decision value will be less than the threshold $\gamma$. So the detector will conclude that there is no availability of the vacant spectrum. On the other hand, if H1 is true then the received signal has both signal and noise, the decision value will be larger than the threshold $\gamma$. So the detector concludes that the vacant spectrum is available.

The threshold value is chosen so as to control the parameters such as False alarm probability (Pf) and Detection probability (Pd).

## III. SYSTEM DESCRIPTION

In this proposed system WIENER KHINTCHINE theorem is used to detect the energy of a CR users. Here the randomly received signals are converted from time domain to frequency domain. Fourier transform is taken to the periodic and deterministic signals . ACF of Randomly received signals is equivalent to that of the Fourier transform of original signal spectrum. Using this criteria frequency range and then power components of the received signals can be obtained.

### *A . WIENER KHINTCHINE THEOREM*

Wiener-Khintchine phenomenon express that the ACF R($\boldsymbol{\delta}$) and the spectral power density S($\boldsymbol{\omega}$) are the Fourier transform, or the inverse of Fourier transform,respectively, of each other.

ACF (Autocorrelation function) of a output system = Product of F.T [ACF of input systems].

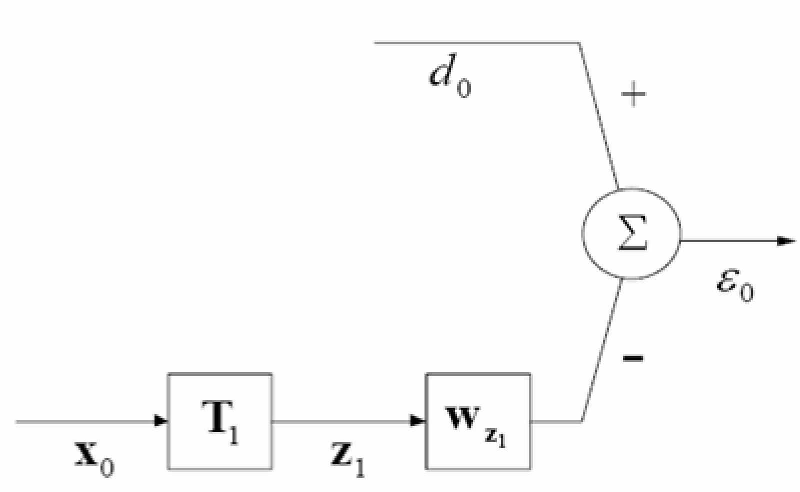


Fig.3. The transform domain wierner filter

Let x(t) be a real wide sense stationary process with a autocorrelation function given as follows

$$R_x(\tau) = Ex(t)x(t+\tau).$$

Assume further that $R_x(\tau)$ satisfies the Dirichlet conditions& implies that $R_x(\tau)$ is absolutely integrable.

$$\int_{-\infty}^{\infty} |R_x(\tau)| d\tau$$

Convergence and the Fourier Transforms are

$$\int_{-\infty}^{\infty} R_x(\tau) e^{-j2\pi f\tau} d\tau$$

While we formally compute the stationary ACF $G(\tau)$ using the Wiener khintchine relationship, obtaining the contradictionary results as follows

$$G(\tau) = \int_{-\infty}^{\infty} \frac{1}{2\pi\omega^2} e^{i\omega\tau} d\omega \sim \tau.$$

The contradiction comes to surface if we now try to compute $S(\omega)$ using $G(\tau)$. Here it is clear that the function f(x)=x is not a square-integrable on the interval $(-\infty, \infty)$ , implies that its Fourier Transform does not exist. It means physically the Wiener process is not a stationary process.

*B. NEED FOR WIENER KHINTCHINE THEOREM*

This theorem is most widely used to analyze a LTI (Linear Time Invariant)systems, in which the input and output functions of a systems are not integrable squarely.

## IV.SIMULATION RESULTS

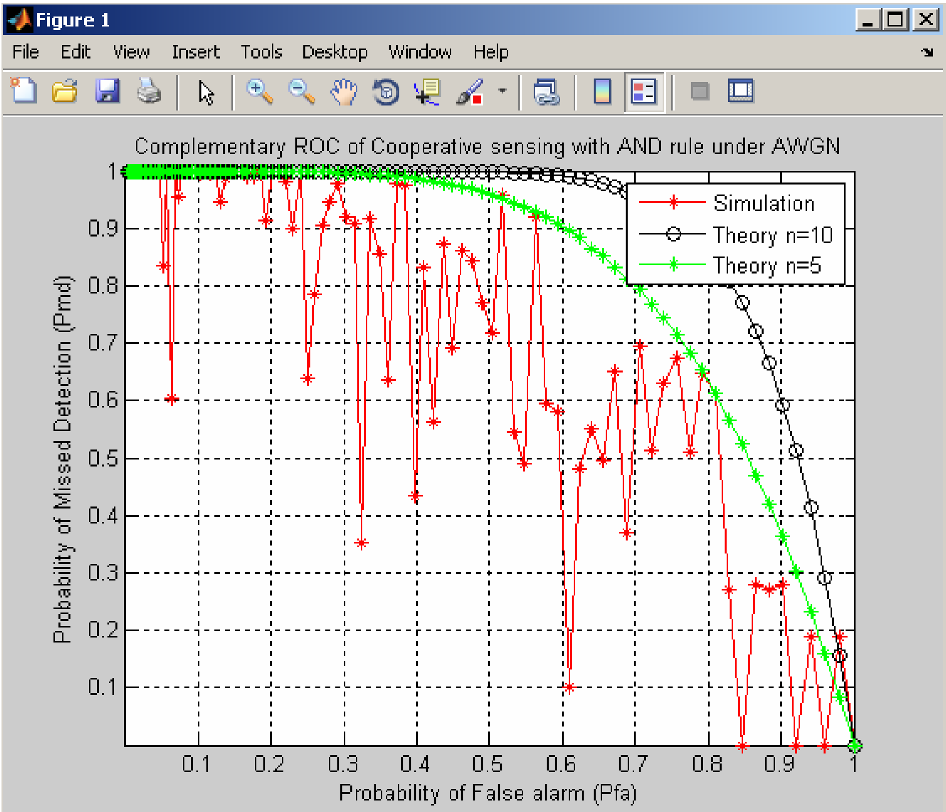


Fig.4. Probability of miss detection (Pmd) Vs Probability of false alarm(Pfa).

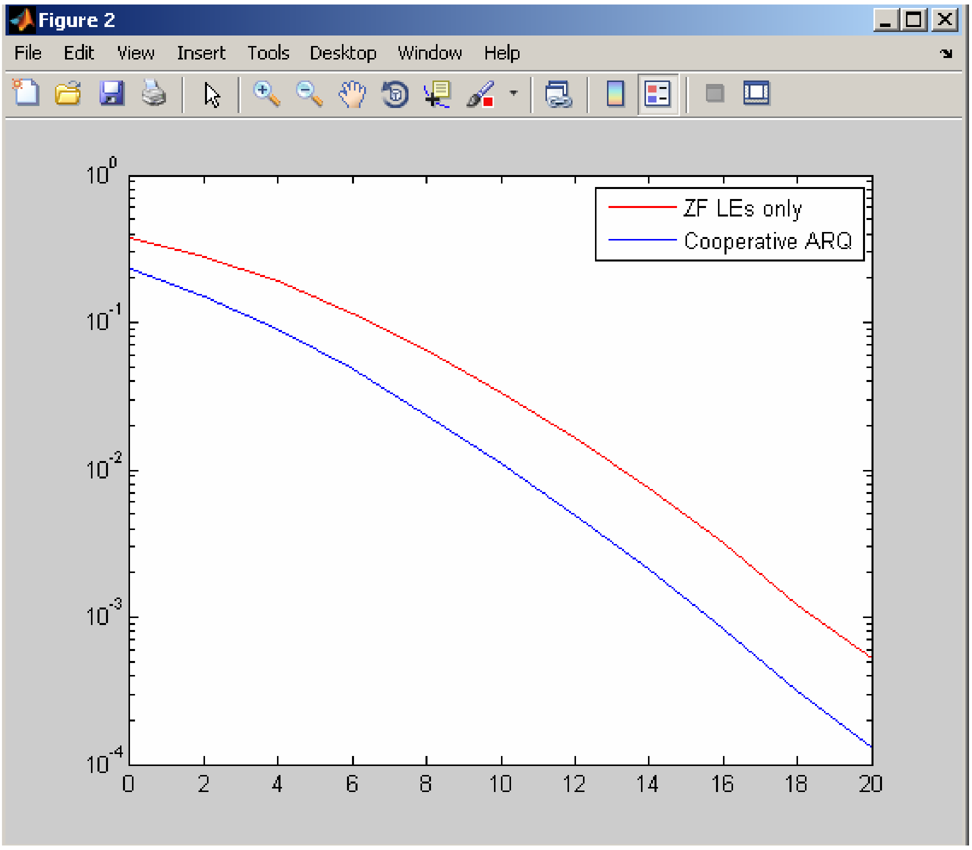


Fig.5. ZF LES Vs Cooperative ARQ

As shown in fig.4. the simulation results states that the plot of probability of miss detection (Pmd) Vs Probability of false alarm(Pfa). The probability of miss detection (Pmd) varies exponentialy with the Probability of false alarm(Pfa).

## V. CONCLUSION

Thus the wiener khintchine theorem has been implemented to detect the energy of a received signal . The simulation results shows that the probability of false alarm(Pfa) & probability of misdetection(Pmd) should less than that of the probability of detection(pd).Hence this theorem is very useful in finding the energy of a OFDM spectrums. This wiener filter based energy detection is better for LTI systems.

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