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CORRELATIVE ANALYSIS OF CYCLOSTATIONARY FEATURE DETECTION AND ENERGY DETECTION USING SIMULINK

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ABSTRACT

Cognitive radio is one of the modern techniques for wireless communication systems to utilize the unused spread spectrum effectively.A cognitive radio is an Smart radio that can recognize the idle frequenciesalso termed as spectral holes or white spacesand allot them for the use of unlicensed secondary users.Around 78 to 88 percent of the radio spectrum is left unutilized at any period of time, while at the same time some of the regions of spectrum suffer from congestion simultaneously.In our present work we have Correlated Cyclostationary feature detection and Energy detection technique for spectrum sensing with their merits and demerits on Simulink tool.

The basic functionality of a cognitive radio is to sense the spectrum accurately by avoiding any chances for interfering with primary or licensed users. Spectrum sensing can be performed either in cooperative or non-cooperative method. Spectrum sensing is also a very effective method to detect spectrum holes and to utilize them. We have implemented spectrum sensing technique in these experiments.

Keywords:- Cognitive Radio (CR), Cognitive Radio Networks, Spectrum Sensing (SS), Energy Detection (ED), Cyclostationary Feature Detection (CFD), Primary User (PU), Secondary User (SU) Software Defined Radio (SDR)

I. INTRODUCTION

Different communication systems such as medical, broadband mobile telecommunication, marine communication, defense and emergency services utilize the radio spectrum. Wireless services and communication is very important for social and economic development in today's world. The requirement of radio spectrum is increasing rapidly because of this advancement in wireless systems.

To enable future wireless communication services, the radio spectrum management is a very important element. The utilization of the radio spectrum must be responsive, active, and flexible to the present needs. Today every wireless system has its own license to avoid interference. In case of new technologies it is difficult to operate in their radio spectra because they are already engaged by government and commercial operators[1][3][5].

For example, it is not so easy to reclaim spectrum bands which are already licensed. A new scheme of spectrum licensing was adopted by the Federal Communication Commission (FCC)[5] and the Swedish Post and Telecom

Agency (SPTS). Both parties have chosen to divide users into two categories; such as a licensed user (primary user) and an unlicensed user (secondary user). Cognitive radio provides an opportunity to secondary users to use spectrum that are free for the moment (white space). Cognitive radio also provides the ability for the radio to take decisionsabout its operations and behavior according to its surrounding environment in order to improvethe service[1][2].

II. COGNITIVE RADIO

The main objective of cognitive radio is to achieve efficient spectrum use by enabling dynamic spectrum access. FCC has defined cognitive radio as a radio that can change its transmitter parameters based on interaction with the environment in which it operates[1][5]. Cognitive radio users are called secondary users (SUs), while the owners of licensed bands are referred to as primary users (PUs). A network that uses CR technology is called Cognitive Radio Network (CRN), as shown in Figure 2.11.

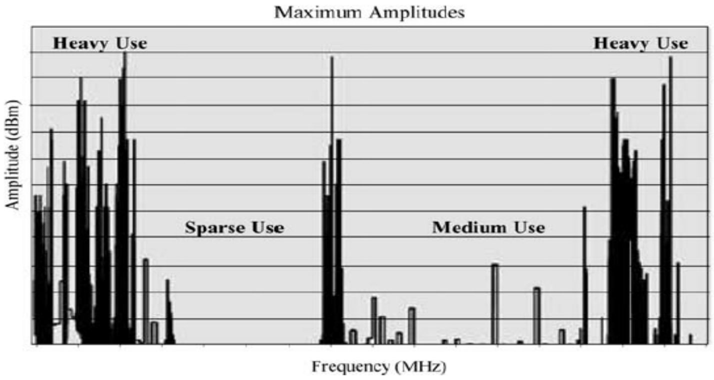

Figure 2.10 Spectrum Utilization

Many studies have been conducted to develop radio devices with CR characteristics. Mitola is the first to present the idea of CR based on a software-defined radio platform to demonstrate the main characteristics of CR, which are cognitive capability and reconfigurability[1][5][8]. Cognitive capability enables CR users to interact with the spectrum environment, while reconfigurability allows CR devices to change their transmission parameters.

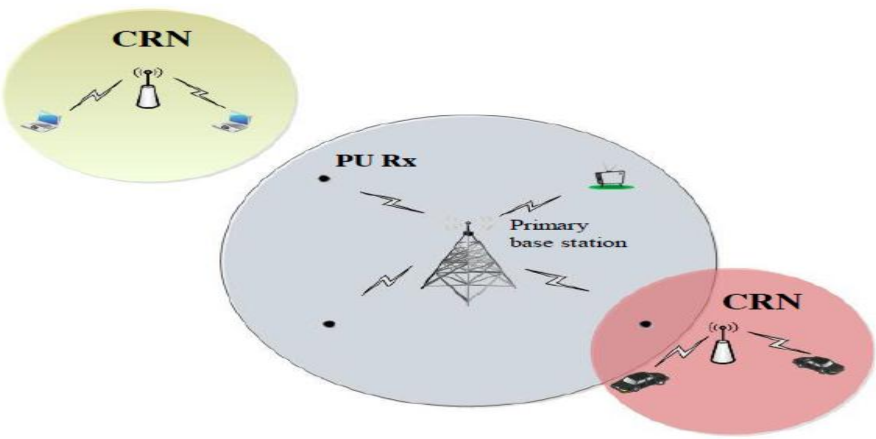

Figure 2.11 Cognitive Radio Network

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They also define the cognitive cycle, as shown in Figure 2.12. In order to perform this cycle, CR must have four components. The first and most vital component is spectrum sensing (SS), which is the ability to detect unused frequencies. The second component is spectrum management, which is the analysis of the available frequency holes so as to choose the one that satisfies certain quality-of-service requirements [6][9]. The third component is spectrum mobility or handoff that guarantees that secondary users are able to seamlessly transit to use another frequency with no connection loss once the primary user is detected. The forth component is a spectrum-sharing technique that determines the spectrum-scheduling mechanism. Figure 1.4 shows the four CR components. Using cognitive radio also requires significant changes to current regulations and policies on spectrum use, which may open a secondary market for the spectrum [1][7][9].

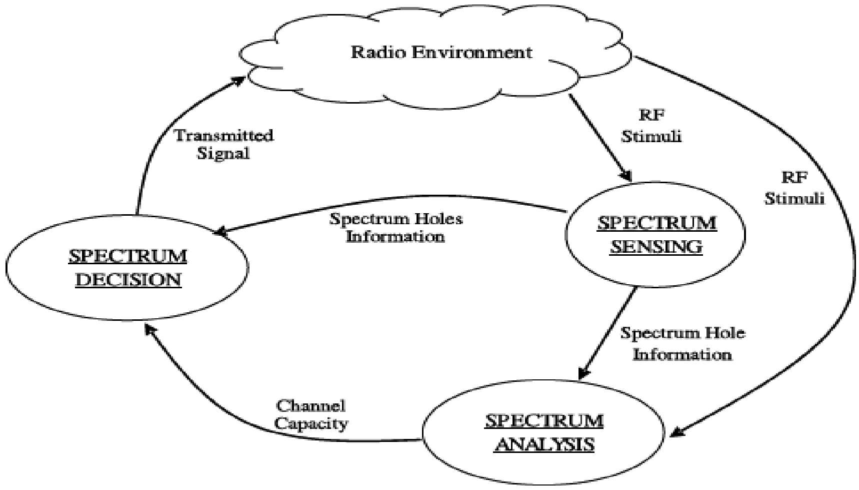

Figure 2.12 Cognitive Cycle

III. ENERGY DETECTION

The straight forward method for detecting unknown signals is Energy detection. When a primary user is assumed to be unknown to the secondary receivers detector, it will become an energy detector, also referred to as radiometers. The energy of a received wave form can be measured by squaring the output of band pass filter with a bandwidth W, and then integrating the received power over a time interval T. The output of the integrator is compared with a predefined threshold to determine presence or absence of primary user[2][10][13].

Figure 3.10 shows a Simulink based model for energy detection using for non-cooperative systems. Here, a random integer generator is used as the input signal and then is QPSK modulated before passing through the AWGN channel. This output is then passed through a band-pass filter and an FFT to get the corresponding coefficients. The signal is converted from time domain to the frequency domain by the FFT block. The magnitude of the received signal is then taken and it is squared.A minimum amount of signal is considered to be noise. The received signal is assumed to be present if and only if the threshold is crossed. This is done with the help of a relational operator[2][5][6].

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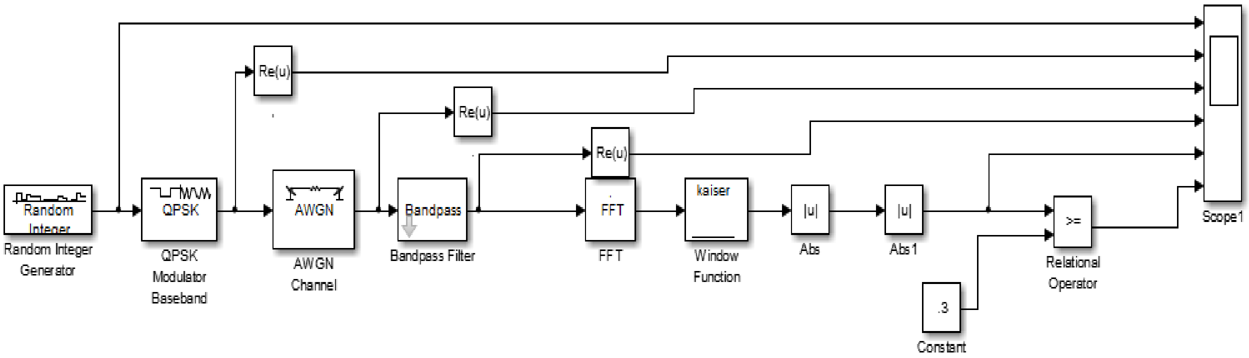

Figure 3.10 Simulink model for Energy Detection

Figure 3.11 shows the threshold comparison of 5 users using energy detection (ED) method. Energy detection blocks are sculptured as many users (5 no.) are required. There are 5 users with different signal values which are compared with thresh-old value. Threshold value is set at .5 and is generated using constant block. Relational Operator compares the input signal value with threshold signal value (.5) and the difference of both values shown on Scope.

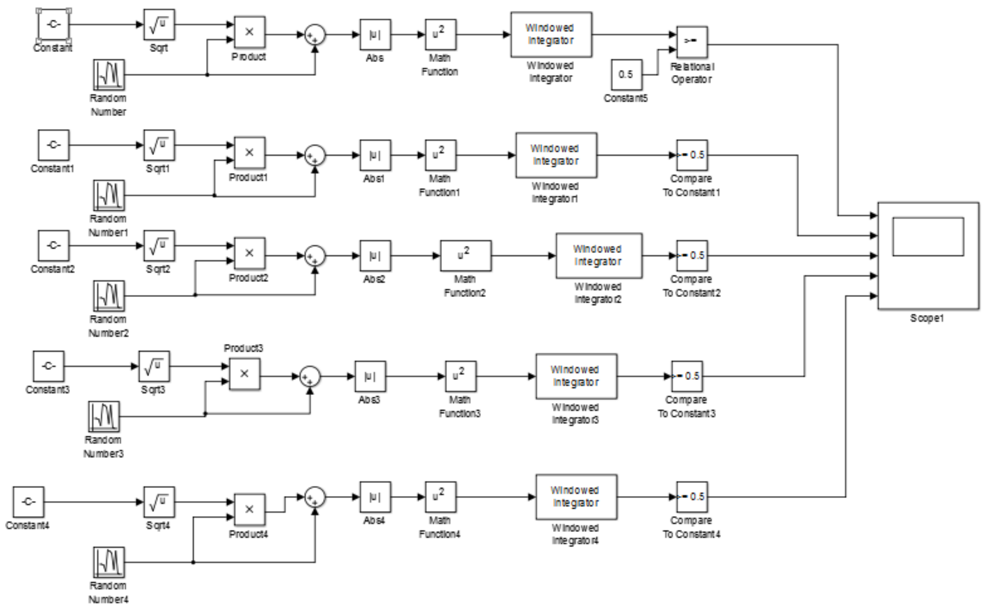

Fig. 3.11 Simulink model for Energy Detection with 5 users (comparison of threshold)

IV. CYCLOSTATIONARY FEATURE DETECTION

Cyclostationary feature detection method is also called as spectral correlation method because it uses cyclic correlation function for detecting present of signal in a given spectrum. These process having periodicity in statistical property like mean, autocorrelation are Cyclostationary. By using periodic statistics of primary user waveform, CR can detect random signal in presence of noise. And these features are extracted using spectral correlation function.

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Figure 4.10 shows Cyclostationary feature detection (CFD) model. Modulating signal i.e. input signal which has 2 KHz frequency, is given to the AWGN channel Additive white Gaussian noise (AWGN) is a basic noise model or also used as channel model that occur in nature with constant spectral distribution. Additive because it is added to any noise[11][8][13]. White because it has uniform power across the frequency band. Gaussian because it has a normal distribution in the time domain. The AWGN channel is a good model for many satellite and deep space communication links. After that signal is passed through filter. Here band pass filter is used to pass particular band of frequency and reject the frequencies outside that range. The main function of a filter in a transmitter is to limit the bandwidth of the output signal to the band allocated for the transmission. Then it is converted into the digital signal. Quantizer is the process of mapping a large set of input values to smaller set such as rounding values to some unit of precision. After that signal is passed through the FFT block which convert time domain signal into frequency domain signal. Windowing technique is used for reduce undesirable oscillation in the band. After windowing function signal is processed for autocorrelation function. In this autocorrelation function signal correlates with itself. For that product block is used in which signal can multiple with its conjugate function. Now absolute value of signal is compared with constant value for detecting the primary user[3] [2] [5].

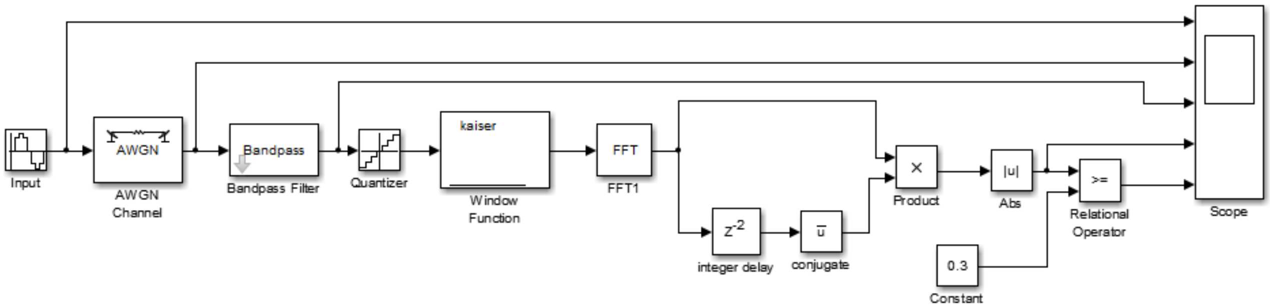


Figure 4.10 Simulink Model of Cyclostationary Feature Detection.

V. RESULTS

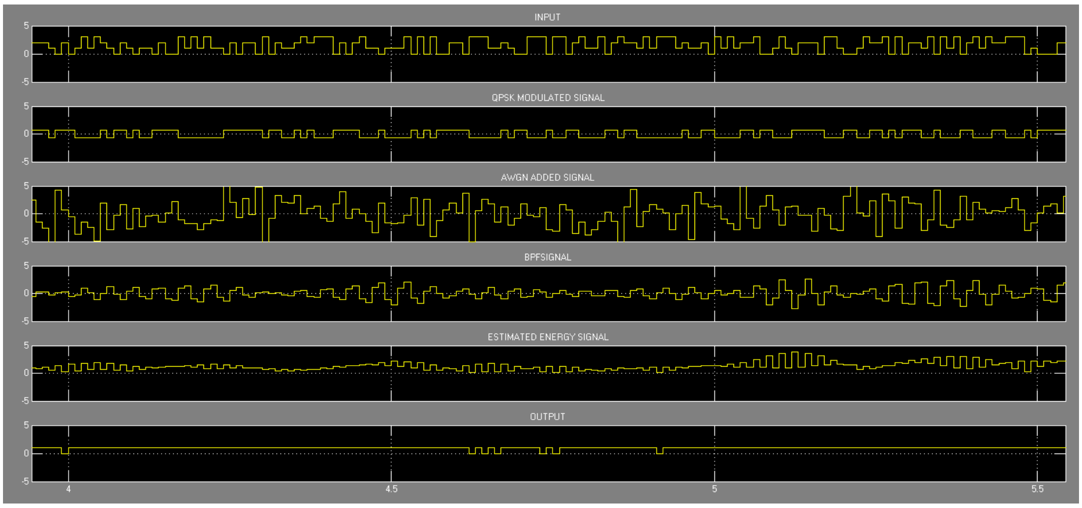
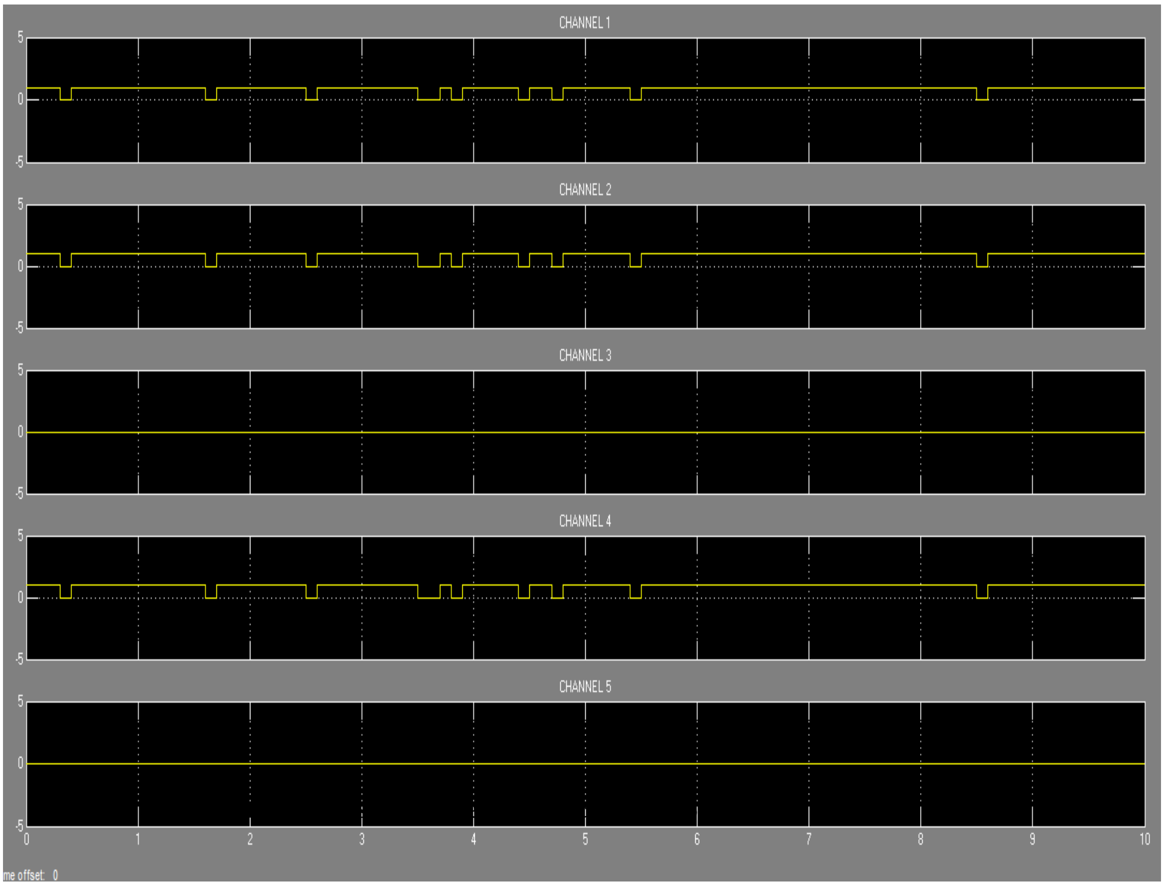


Figure 5.1 Simulation Result of Energy Detector

The figure 5.1 shows the simulation results (display of the scope), which shows the original transmitted signal from the random integer generator, the QPSK modulated signal, then the filtered signal and then the squared magnitude of the modulated signal, and finally the output after the signal has been compared with the pre-determined threshold value. The threshold is set to 0.3 and if the user crosses the threshold value, only then the user is present, otherwise the user will be idle (spectral holes) and at that instant the secondary user can utilize that space.

5.1 Simulation of Energy Detection with 5 Users

The figure 5.21 shows threshold comparison of 5 users using energy detection (ED) method. There are 5 users with different signal values which are compared with threshold value. Threshold value is set at 0.5 and it is generated using a 'constant' block. The 'Relational Operator' block compares the input signal value with threshold signal value and the difference of both values is shown on the Scope for each of the 5 users.The user who will cross the threshold value is assumed to be present and who will not cross thresh-old value is assumed to be idle. As shown in graph that 1st, 2nd and 4th user cross the threshold value so they are assumed to be present. 3rd and 5th user does not cross the threshold value so they are assumed to be idle means there spectrum is free to access. So secondary user (SU) can use that spectrum.



5.2 Cyclostationary Feature Detection Model Results

The figure 5.31 represent Simulink result for detecting primary user. For that Input signal is passed through channel, filter, FFT block and windowing technique. After that it takes the absolute value which compares to the constant value through relational operator and generates the result. Final result shows presence and absence of primary user, in which peak value shows presence of primary user.

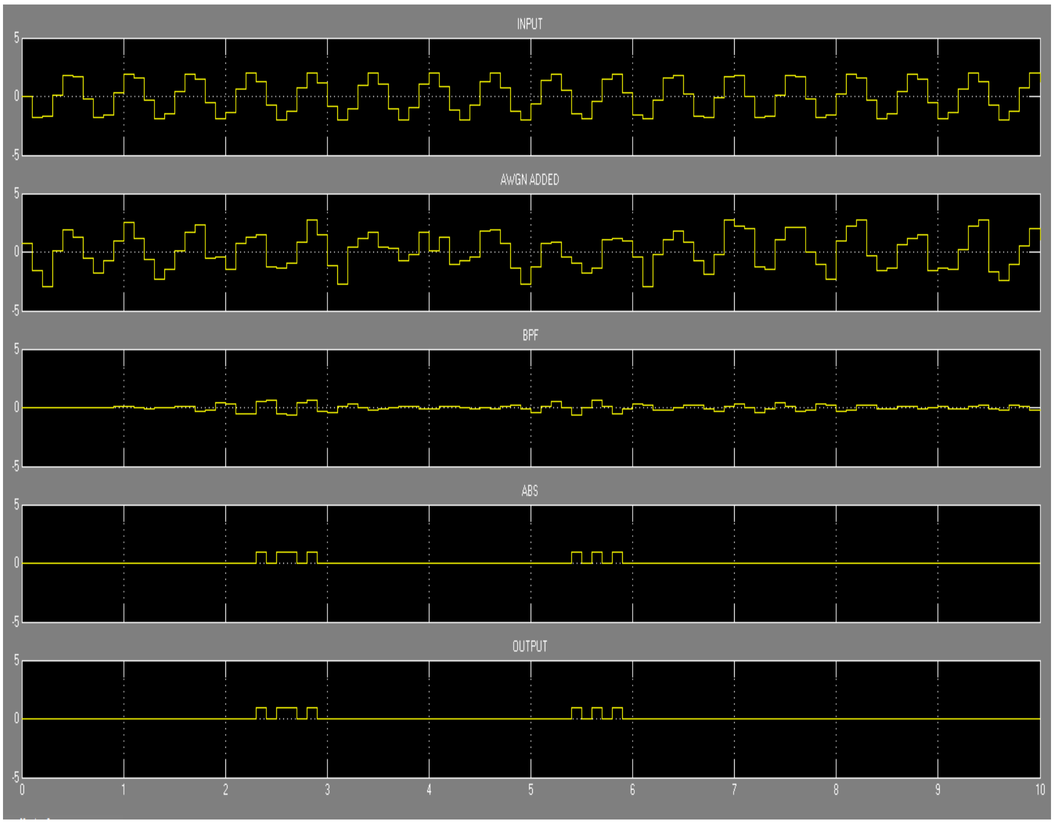


Figure 5.31 Simulation Result of Cyclostationary Feature Detection.

VI. CONCLUSION

In this Paper we have executed Simulink based spectrum sensing methods, Energy detection and Cyclostationary feature detection Method. The Energy detection (ED) method for spectrum sensing (SS) is carried out for 5 users. The Energy Detection method shows the degraded results due to large presence of noise which is overcome by the Cyclostationary feature detection (CFD) method. The appearance or non-appearance of the licensed user is selected based on the threshold value which is manually adjusted. In Cyclostationary Feature detection detectors employs the inherent periodicity of the modified signals. Based on the features the Cyclostationary feature detection (CFD) method is better as compared to energy detection (ED) method**.** Although this method increases the complication of the system but still user is present under heavy noisy environment which proves that noise effect is very small.

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