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Cyclostationary Feature Detection using Various Modulation Schemes

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Abstract: In cognitive radio various spectrum sensing schemes have always been researched and discussed. An ideal detection scheme should be fast, precise and effective. Cyclostationary feature detection is a detection scheme that fulfils all these criteria (fast, precise and effective). Cyclostationary feature detection also holds the capability to distinguish between the primary user signal and unwanted signal called noise. One major advantage of cyclostationary feature detection method is that in addition to identifying the primary user signal, it also identifies the modulation scheme used by the primary user. This paper explores the cyclostationary feature detection method under different modulation schemes that are BPSK, QPSK, and 8-PSK. In BPSK One primary peak (centre peak) and one secondary peak obtained, in the case of QPSK One primary peak (centre peak) and two secondary peaks obtained and in the case of 8-PSK One primary peak (centre peak) and four secondary peaks are obtained. The output is plotted on graph and various modulation schemes are studied in Cyclostationary Feature Detection method. The Spectral Correlation Function (SCF) is used in this research paper which shows a peak in the centre of graph if primary user is present.

Keywords: Primary User (PU), Energy Detection (ED), Signal to Noise Ratio (SNR), Cognitive Radio (CR), Cyclostationary Feature Detection (CFD)

I. Introduction

A Cognitive Radio is an adaptive multi-dimensionally aware intelligent wireless communication system that learns from its experience to reason, plan and decide future action to meet consumer needs. A Cognitive Radio must be capable of: 1) sensing its environment 2) adapting its physical layer functionality 3) learning from its past experiences to deal with new situations in the future. Spectrum sensing, defined as the task of finding spectrum holes by sensing the radio spectrum in the local neighborhood of the cognitive radio receiver in an unsupervised manner [6].

Spectrum Sensing Techniques

Three conventional methods for spectrum sensing are:

- I) Matched Filter II) Energy Detector III) Cyclostationary Feature Detector.

Cyclostationary Feature

When the primary transmitted signal exhibits cyclostationarity, it can be detected by exploring the periodic behavior of the cyclostationary parameter. This method is more robust to noise uncertainty than energy detection. Although a cyclostationary signal can be detected at lower signal-to-noise ratios compared to other detection strategies, cyclostationary detection is more complex than ED. Moreover, similar to the case of the matched filter detection, it requires some prior knowledge about the primary signal. 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. 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 [7-9].

II. Background

Paper [1] offers light-weight cooperation in sensing grounded on hard verdicts to diminish the sensitivity necessities of individual radios. Cognitive Radios have been progressive as a technology for the unscrupulous practice of under-utilized spectrum since they are able to sense the spectrum and use frequency bands if and only if no primary user is detected. However individual radio might face a deep fade, as the required sensitivity is very challenging. In paper [2] spectrum detection performance is explored with help of energy detector

scheme in a cognitive radio communication network over channels with multipath fading and shadowing that used for cooperative spectrum sensing. The spectrum detection scheme used is energy detection method. In paper [3], a review of all the existing spectrum sensing approaches for cognitive radio communication is done. Innumerable features of spectrum sensing difficulties are studied. It also familiarizes with the multi-dimensional spectrum sensing perception, External sensing algorithms. Tasks, challenges linked with spectrum sensing are also defined. Cooperative spectrum sensing concept also explored in this paper. Except these, statistical modeling of network traffic and deployment of these static models for the precise estimation of the behavior of licensed user is also done. In paper [4] examination of cognitive radio based on Ultra-Wideband (UWB) in short range systems is studied. UWB is a wireless technology .UWB can transfer between very short data rate and very high data rate, and also between short range and long range distance applications. Various applications of UWB are high speed data transmission with low power utilization, in military, radars, sensing, tracking, data assembly or even commercial application. Paper [5] explains that the detection presentation is frequently negotiated with multipath fading, shadowing and receiver uncertainty issues. To alleviate these issues, cooperative spectrum sensing has been shown to be an effective method to improve the detection performance by exploiting spatial diversity.

III. Simulation Models of Proposed System

Figure 1 and Figure 2 are the proposed models for Cyclostationary feature detection without modulation scheme and with modulation scheme respectively. A random discrete signal is taken and modulated using different modulation schemes BPSK and QPSK. Noise is added by AWGN block. After that modulated signal is passes through CFD (cyclostationary feature detection) block. The CFD basically contains filters, ADC, quantizer , encoder, fft blocks. As it is already known to us that cyclostationary Feature Detection technique is not as simple as other Spectral Sensing Techniques. Cyclostationary feature detection method deals with the inherent cyclostationary properties or features of the signal. Such features have a periodic statistics and spectral correlation that cannot be found in any interference signal or stationary noise. It exploits this periodicity in the received primary signal to identify the presence of primary users, and that is why the cyclostationary feature detection method possesses higher noise immunity than any other spectrum sensing method. The received signal is obtained after demodulate the signal or in other words we can say that the signal is received at output after converting signal in its original form. The output is taken using spectrum analyzer which displays the output in a graphical form which can be easily understandable or readable for observer.

The output plot thus obtained is the cyclic SCF. The cyclic SCF contains a peak at the center if there is a primary user in the spectrum. In the absence of any primary user, (i.e. equivalent to inputting all zeros) the cyclic SCF will not be having any peak. Thus the outputs of feature detector with and without a primary user are obtained.

Fig. 1: Block diagram of Cyclostationary feature detection

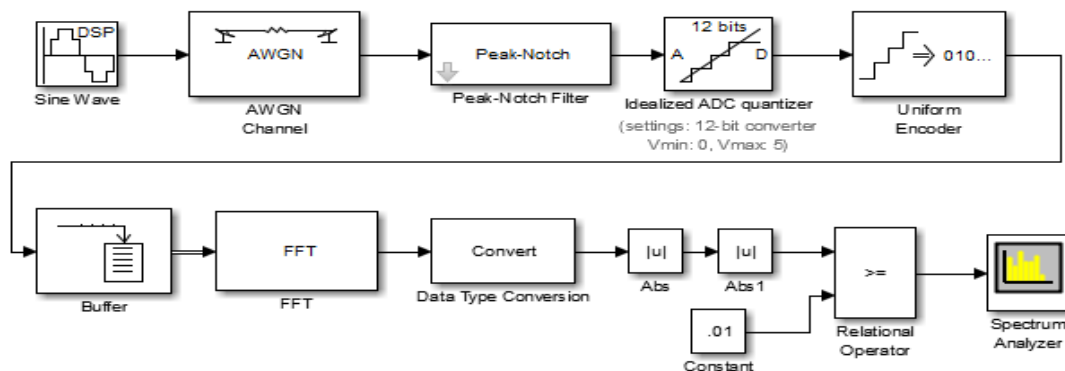
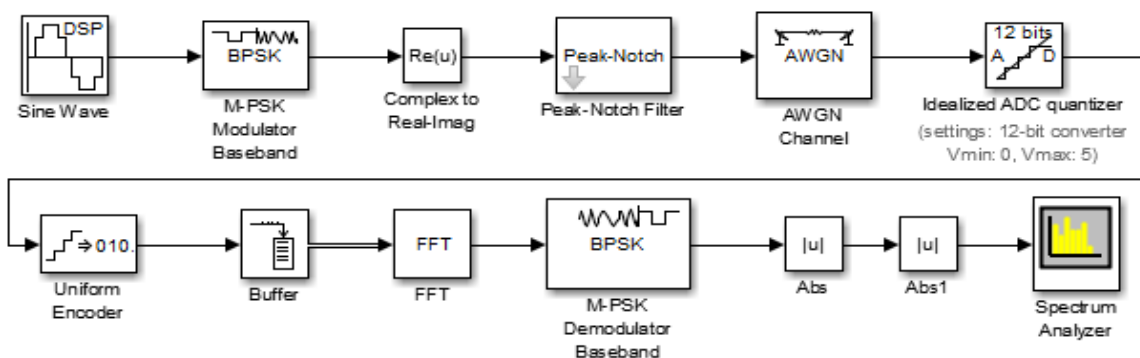


Fig. 2: Block diagram of Cyclostationary feature detection using BPSK.



IV. Result and Discussion

Table 1: Input Parameter

Detection scheme	Cyclostationary Feature Detection
Modulation scheme	BPSK,QPSK,8-PSK
Channel	AWGN
Operating Frequency	200 Hz

Table 2: Output Parameter

Cyclic Spectral Correlation Function	SCF
Probability of Detection	0 to 1

A random signal is taken and modulated using BPSK,QPSK,8-PSK techniques. The operating frequency chosen is 200Hz.Noise is added in the signal and then signal passes through AWGN channel.The received signal is demodulated and fed to the Cyclostationary Feature Detection (CFD) block. Here only BPSK modulation is shown in fig 2 . Modulation schemes like QPSK,8-PSK are not shown here but all these techniques are almost similar to BPSK modulation scheme.The difference is only that the modulator and demodulator block have to replace as per required modulation scheme.

The output obtained is the cyclic SCF. The feature of cyclic SCF is that it contains peak at the center if primary user is present in spectrum. If primary user will not present in spectrum, SCF will not show any peak. Thus the output of cyclic feature detector are obtained with and without primary user.

Figure 3 shows the output of cyclostationary feature detection without using any modulation scheme. A peak is shown in the center of figure which shows that primary user is present . The primary user is shown using cyclic SCF function. The operating frequency is 200 Hz. Figure 4 indicates cyclic SCF when primary user is modulated using BPSK scheme. The modulation scheme can be identified by looking at peaks shown after frequency of 200 hz. Similarly cyclic SCF can be seen in QPSK modulation technique (Figure 5) in which primary user is present and the two secondary peaks between frequency 400hz-600hz are responsible for showing QPSK modulation scheme. Fig 6 shows 8-PSK modulation scheme. In 8-PSK there are 8 Constellation points so that's why 4 secondary peaks are identical between 0hz-200hz frequency. This is how modulation schemes are used in CFD technique.

Fig. 3: Output of cyclostationary feature detection (without using any modulation scheme)

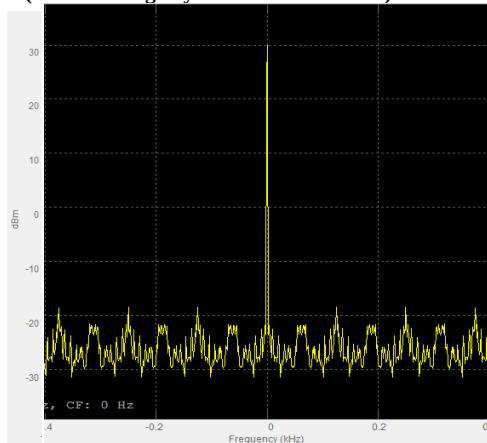


Fig. 4: Output of cyclostationary feature detection using BPSK

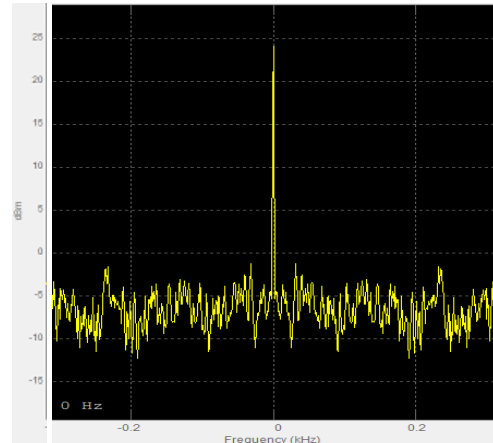


Fig. 6 Output of cyclostationary feature detection using QPSK

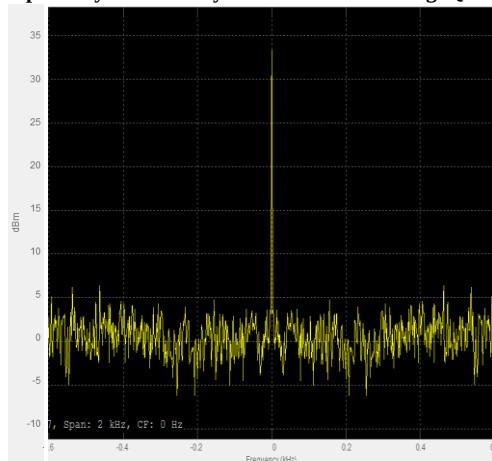
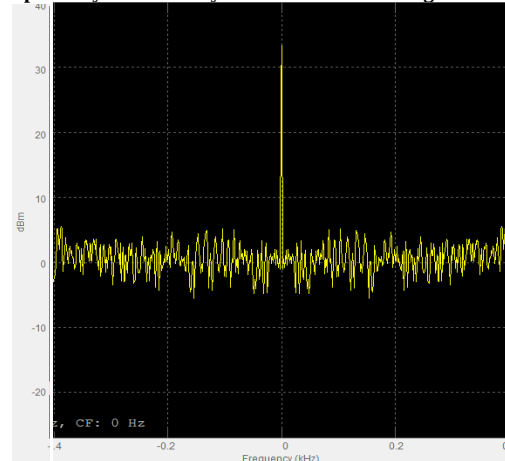


Fig. 7 Output of cyclostationary feature detection using 8- PSK



V. Conclusion

The cognitive radio spectrum sensing can be performed most reliably and efficiently by using the cyclostationary feature detection method. The cyclostationary Feature detectors utilize the periodicity of the modulated signals. Also the modulation scheme employed by the primary user at the transmitter section can be accurately predicted using this method. This is a major advancement of CFD method over all other available spectrum sensing schemes. CFD is done with and without modulation schemes. Modulation schemes used are BPSK, QPSK, and 8-PSK. Other modulation schemes can also be introduced similarly. The research work is continuous on other modulation schemes and researcher hopes to get ride on the obstacles coming in to apply more modulation schemes.

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