SIGNAL CLASSIFICATION OF SECOND ORDER CYCLOSTATIONARITY SIGNALS USING BT-SCLD AND VBT-SCLD TECHNIQUES

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Abstract

Signal Classification and parameter estimation of cyclostationary signal is an vital issue for various security applications like civil and military applications such as LTE, spectrum detection, and spectrum maintaining in cognitive radio systems. Cyclostationary signals is one, that exhibits a statistical property to categories whether the signal is belong to be a probabilistic approach or a deterministic approach. However there are many criteria's to be developed, led to investigate the problem in digital modulation. The problems are overcome by using different algorithms which includes Single Carrier Linearly Digitally modulated signals (SCLD), Orthogonal Frequency Division Multiplexing (OFDM), Block Transmitted-Single Carrier Linearly Digitally modulated signals (BT-SCLD), Variable Block Transmitted-Single Carrier Linearly Digitally Modulated signals (VBT-SCLD). Analytical expressions are resulting for the cyclic autocorrelation function (CAF), cyclic spectrum (CS), and equivalent cycle frequencies (CFs). The block transmitted single carrier linear digitally modulated signals to accomplish a sensibly good performance at signal-to-noise ratios(SNR) for different channel conditions, still using a short sensing time. But the Block transmission system which is used for only fixed block size. So, in order to overcome this problem, Variable block transmitted single carrier modulated signals system consists of several different block size and used to enable a transmitter in variable blocks based on the bits. That is the size varies dynamically based on incoming signal. Furthermore, the conditions for avoiding aliasing in the cycle aliasing and spectral aliasing domains are obtained. The paper demonstrates that the effectiveness of proposed algorithm under less signal-to-noise ratios (SNRs), various short sensing times, and reduced Bit error rate.

Keywords—** Signal classification, Cyclostationarity statistics, Blind parameter estimation, Cyclic autocorrelation function and Signal-to-Noise Ratio.

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1. INTRODUCTION

Blind parameter estimation of communication signal plays a vital role in various security and commercial environments, such as, Long Term Evolution (LTE), Cognitive Radio (CR)systems. A cyclostationarity based approach to the blind parameter estimation, which derives the estimated parameters from both time domain and frequency domain using the second-order Cumulant. It is shown that detection and estimation in two domains can shows the improvement of probability accuracy [1].

On the one hand ,the reason for this lies in the information deficit of the data, which is the result of finite measurement precision by the noise and on the other hand on data mining procedures that cannot sufficiently treat the statistical nature of the data [2]. Within this work introduce a blind parameter estimation method that is able to reveal parameters that can be used in a wireless communication. In contrast to traditional approaches produces a classification of signals in the communication environment effectively.

The cyclostationarity properties of signal, generally subjugated for various purposes: signal detection, signal classification, signal synchronization and blind parameter estimation, in which the blind estimation of signal parameters has been investigated only in few recent years. The detection procedure is mainly empirical and not precise for estimation accuracy [3,9] By checking the presence based on a threshold. In addition, the utilization of cyclic statistic properties only applied in time domain or frequency domain does not make full use of the cyclostationarity properties of Orthogonal Frequency Division Multiplexing (OFDM) and Single Carrier modulated (SC) signal [4]. By inserting a cyclic prefix before each transmitted block longer than the channel order, OFDM can effectively turns a frequency selective channel into a flat-fading channel. This allows, for simple one vector equalization at the expense of a efficiency level 10–25%. Due to the various symbols required by the cyclic prefix as well as sensitivity increased to timing, synchronization, transmission non-linearities by the non constant modulus of OFDM signals [5].The classification diagram for cyclostationary signals is shown in Fig-1.

Different approaches are explained based on conventional Single Carrier (SC) modulation methods. Then it combined with Frequency Domain Equalization (FDE), this SC approach produces performance similar to OFDM, with basically like the same complexity [4]. In addition, Single Carrier modulation prefers a single carrier, instead of the multiple carriers used in OFDM. So the peak-to-average power ratio for Single carrier modulation signals is smaller. This in spin means that the power amplifier of an SC transmitter require a smaller linear range to support a original average power [3].

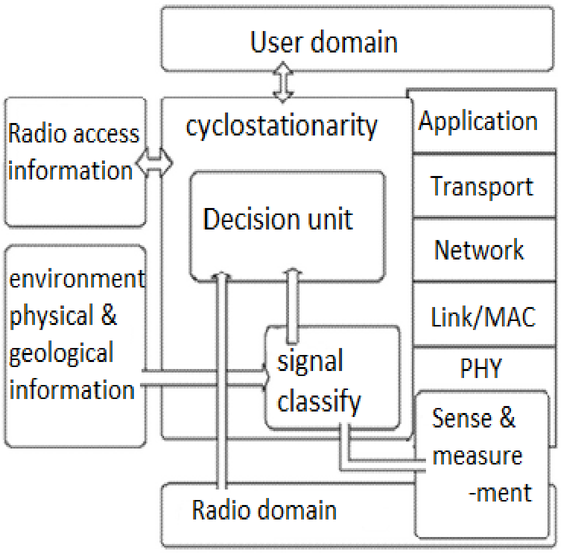

Fig -1: Classification diagram for cyclostationary signals

The new algorithm provides the second order cyclostationarity of Block transmitted single carrier linearly digitally modulated signals (BT-SCLD) its classification and blind parameter estimation. The analytical closed form expressions for the Cyclic Spectrum (CS), Cyclic Autocorrelation Function (CAF), Complementary Cyclic Spectrum (CCS), Complementary CAF (CCAF) and the different Cycle Frequencies (CFs) are derived.

In section II, discusses cyclostationary signals and modulation classification techniques. Section III shows the different signal classification schemes. Section IV explains the Blind parameter estimation technique. Section V evaluates the orthogonal frequency division multiplexing performance and block transmission schemes through simulations and finally, section VI about the conclusion.

2. RELATED WORKS

In this section, cyclostationary signals and modulation classification with parameter estimation are analysed.

2.1 Cyclostationary Signals

A cyclostationary process is a signal having statistical properties that vary regularly with time and frequency. This process can be considered as multiple stationary processes. There are two different approaches in the treatment of cyclostationary processes.

The probabilistic approach is to view measurements of a distributions. An alternative, the deterministic approach is to measure a one time series, from which a probability distribution can be express as the fraction of time that events occurs over the permanent of the time series. In approaches, the process or time series is consider to be cyclostationarity if its connected probability distributions vary periodically with time. An important special case of cyclostationarity signals is one that maintains cyclostationarity in second-order statistics (e.g., autocorrelation function).

Cyclostationarity is often preferred in digital communications when a human made signal such as the interference from other channel communicators is present in the frequency band. Especially when a communication system employs linear modulation, which is one of the most popular digital communication modulation scheme, it is well known that the second-order cyclostationarity statistical property of the transmitted signal is occupied by a wide sense cyclostationarity process rather than by a wide-sense stationary (WSS).

2.2 Cyclostationary Signatures

Cyclostationary signatures as an convenient tool for upcoming a number of the real challenges associated with network coordination in CR and multiple spectrum access applications. P.D Sutton et al [6] proposed that, cyclostationarity signatures may be also used to up bring a number of limitations associated with the use of natural cyclostationary features for signal detection and analysis.
Using a well flexible cognitive radio systems platform, the implementation of a full OFDM based transceiver using cyclostationarity signatures Robust, less complexity approaches for signature classification, generation, signal detection and analysis were presented. The use of cyclostationary signatures to attain signal detection, network identification and frequency assignation were examined.

2.3 Modulation Classification

Modulation classification can be crystallized, Likelihood Based (LB) and another one Feature Based (FB) methods [13].

- *Likelihood Based (LB)*: The likelihood function is based on the received signal and the decision is made comparing the likelihood ratio beside a threshold.
- *Feature Based (FB)*: **S**everal interests are usually working and a decision is made based on their exact values. These interests are usually chosen in an ad-hoc way.

A solution offered by the LB algorithms is best possible in the Bayesian sense, it reduces the distribution probability of wrong classification. The possible solution suffers from computational complexity, which in major cases of interest gives rise to suboptimal classifiers. Although a feature based method may not be most favorable it is simple to implement, with relevant optimal performance, when designed suitably.

Once the modulation format is correctly identified with various operations, such as signal modulation and data extraction can be afterward performed. In an adaptive communication system, the modulation format can be changed according to the various channel state to high efficiency communication [18]. The main role of Maximum Likelihood (ML) method is, there is an inverted correlation matrix in likelihood function.Usually additional information about the modulation format is transmitted.

2.4 Parameter Estimation

Parameter estimation is the recognition of a number of informations from a source signals, without the help of information or with very little information about the signals. This problem is highly dogged, but useful solutions can be derived under a shocking variety of conditions. Much of the early researches in this field focus on the division of temporal data [10]. However, blind parameter separation is now routinely performed on two or three dimensional data, such as pictures, which may consider no time dimension.

The principle and component analysis, which seeks source signals that are minimally linked or maximally independent in a stocastic or information theoretic sense. The next approach is exemplified by non-negative matrix decomposition, which aims to attain structural constraints on the source signals. These constraints derived from a generative model of the signal, but more commonly used by good experimental performance [11]. A common theme in the next approach is to impose some kind of low-complexity constraint on to the signal, such as sparsity of the signal space [12]. This approach can be particularly use if one requires not the whole signal, but generally it has most prominent features.

3. SIGNAL CLASSIFICATION SCHEMES

In this section, signal classification schemes are classified based on different algorithms.

3.1 Signal Classification

Signal classification is based on the results derived for the second order cyclostationarity signals. Signal classification is performed under the assumption that the signal is present as a result of pre-processing by signal detection techniques. The following classification algorithms are Single Carrier (SC), Orthogonal Frequency Division Multiplexing (OFDM), Block Transmitted- Single Carrier (BT-SC), Variable Block Transmitted- Single Carrier modulation signals (VBT-SCLD). The signal classification is shown in Fig-2.

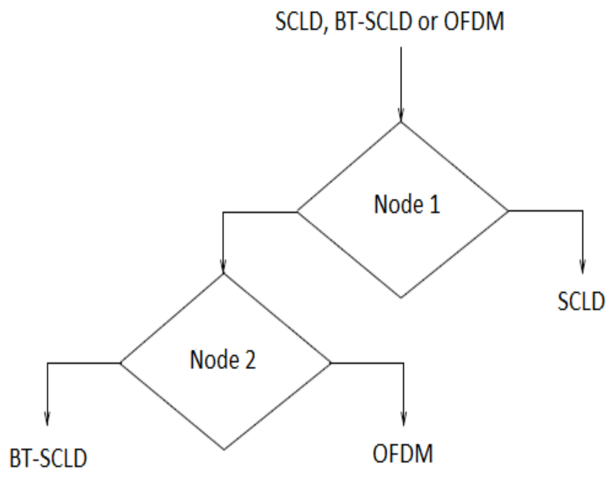

Fig -2: Signal Classification

3.2 Single Carrier (SC) Modulation Technique

Single carrier modulation is a well known technology in many of the past wireless and wired applications, and its Radio Frequency system with linearity requirements. SC modulation uses a one carrier, instead of the several carriers in OFDM, so the peak-to-average power ratio for SC-modulation signals is smaller [10]. This in turn means that the power amplifier of an SC transmitter requires a lower linear range to support a given maximum power which requires low peak power back off.

Among the SC amplitude-modulated signals, a module discriminates the M-QAM from the M-ary amplitude shift keying (M-ASK). SC modulation has less peak-to-average ratio requirements from OFDM, thereby allowing the use of low costly amplifiers. Its performance with FDE is similar to that of OFDM, even for long duration channel delay. An analytical variation of single-carrier (SC) and multi-carrier (MC) transmission is viewed for binary signalling on fading mobile radio channels defined by Rayleigh, Rician, and one-normal distributions. For the same rate of transmission and signal bandwidth, it is demonstrated that the SC transmission system is better to the MC system on the slow fading multipath channel.

3.3 Orthogonal Frequency Division Multiplexing

OFDM transmits several modulated multicarriers in parallel form, which occupies only a narrow bandwidth. Since the channel condition affects the amplitude and phase of each subcarrier, and also equalizing subcarrier's gain and phase does compensation for frequency fading [10].

Generation of the multiple subcarriers is done by performing Inverse Fast Fourier transform (IFFT) at the transmitter on blocks of M data symbols; classification, extraction of the subcarriers at the receiver is done by performing the Fast Fourier transform (FFT) operation on B blocks of M received samples [21]. Frequently, the FFT B block length M is at least 4–8 times longer than the maximum impulse response. One reason for this is to reduce the fraction of overhead payable to the insertion of a cyclic prefix at the starting of each block. The methods providing an blind estimation of the OFDM parameter are vigorous to the context of small guard time compared to the useful part of the guard time in various channel impulse response.

3.4 Block Transmitted-Single Carrier (BT-SC) & Variable (VBT-SC)

Block transmitted single carrier (BT-SC) signals have been introduced as an alternative way of achieving comparable performance, efficiency, and computational cost. This technique does not suffer from carrier synchronization and Peak-to-Average Power Ratio (PAPR). This algorithm needs only a minimal step of pre-processing the signal: after the signal bandwidth and carrier estimation, the signal is selected, filtered, down-converted and sampled. There is no use for the additional information estimation such as signal waveform, symbol timing and additional noise power.

The second order cyclostationarity test is used for signal decision methods. To test the presence of cycle frequency at a minimal delay, a cyclic autocorrelation function estimated and compared fromt threshold value. BT-SC algorithm reduced the amount of aliasing (Spectral and Cycle aliasing) in the transmission signals. The analytical closed form expressions for the Cyclic Spectrum (CS), Cyclic Autocorrelation Function (CAF), Cyclic Spectrum (CS), Complementary CAF (CCAF), and the corresponding Cycle Frequencies (CFs), and the conditions for avoiding spectral aliasing, cycle aliasing frequency domains are derived.

VBT-SC provides for the usage in variable block size. That is the block size dynamically varied by using bits measurement in the incoming signal. then the reduced block automatically decreases the bit error rate.

To minimize cycle aliasing, it follows that sampling frequency *fs* should satisfy the condition

$$fs >= 4W$$

To minimize aliasing in the spectral frequency domain, sampling frequency *fs* should satisfy the Nyquist condition

$$fs >= 2W$$

4. BLIND PARAMETER ESTIMATION SCHEME

In this section Blind parameter estimation is explained based on block transmission algorithm.

4.1 Blind Parameter Estimation

The second order cyclostationarity of BT-SCLD signals are used to construct an algorithm for the blind parameter estimation of B block transmission parameters. The algorithm is to determine the blind parameters in two steps: First step is, the number of data symbols in a B block is estimated by exploiting the accessible of cyclic prefixed (CP) induced peaks in the starting signal cyclic Autocorrelation function (CAF) magnitude delay and zero cyclic frequency (CF). Second is, the CAF magnitude is estimated at the certain delay obtained in first step with certain range of minimal positive cycle frequency.

5. PERFORMANCE ANALYSIS

5.1 Simulation and Performance

The simulation model is implemented by using MATLAB tool. OFDM and BT-SCLD signals with a 16-QAM constellations were simulated. Orthogonal Frequency Division Multiplexing is a method of encoding digital data on multiple subcarrier frequencies. And this the accepted scheme for high band digital communications. Over single carrier schemes is its ability to cope with different channel conditions. OFDM decomposes the maximum band into a set of single band subchannels with different Quadrature Amplitude Modulation in frequency range 5GHZ. Block transmission scheme mentions the single carrier modulation with the fixed range of block size. The OFDM and BT-SCLD signals working a root raised cosine pulse shape.

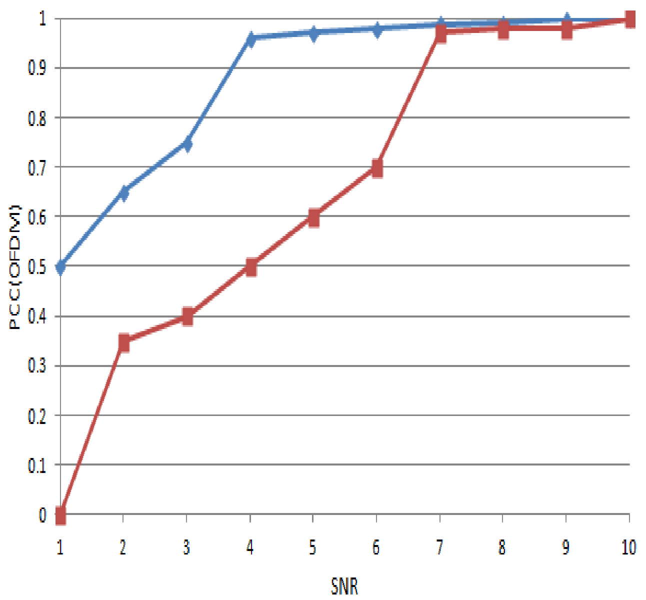

Fig -3: Performance of OFDM (L=N/8)

The probabilities of correct classification of OFDM and BT-SCLD signals are plotted as a function of SNR in Fig-3 and 4 respectively for same signal. SNR is a measurement, describes that how much noise in the output device in a relation to the input signal level.

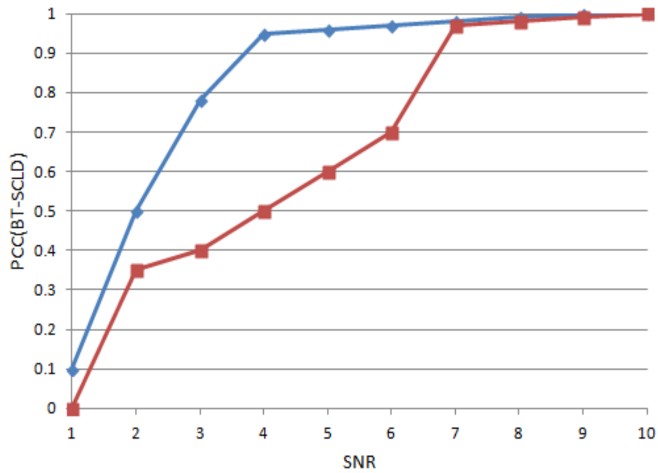

Fig -4: Performance of BT-SCLD (L=N/8)

If the SNR increases th accuracy will be more. Without the loss of generality, piece variance constellations were determined. sensing times of 5 ms and 10 ms were used.5ms indicates in red and 10ms in blue colour. N is mentioned as subcarriers, Here N=32

Results for the performance of the proposed classification algorithm for BT-SCLD signals having various CP durations are presented. As expected, a reduction in the CP duration badly affects the performance. This is explained by the reduction in the correlation that resulting from the reduced CP duration.

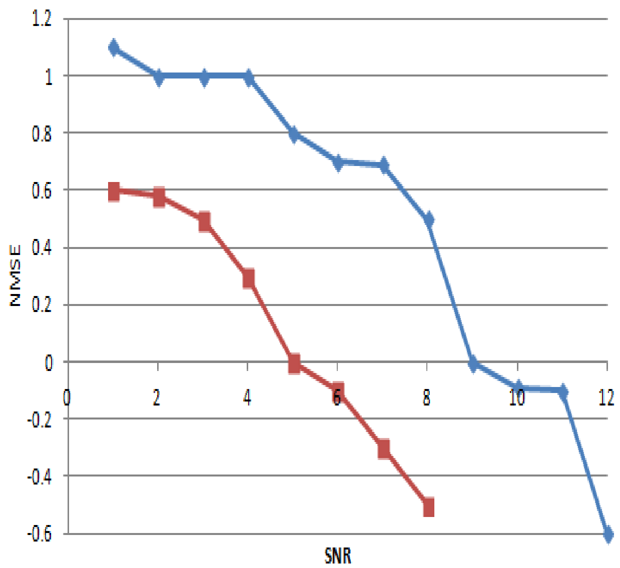

Fig -5: Performance of BT-SCLD (NMSE vs SNR)

Fig-5 represents the performance of BT-SCLD signal. And that is measured by Normalised mean square error with SNR. Normalised mean square error is the process of estimation from over all deviations to predicted and measured values. Here L=N/8.

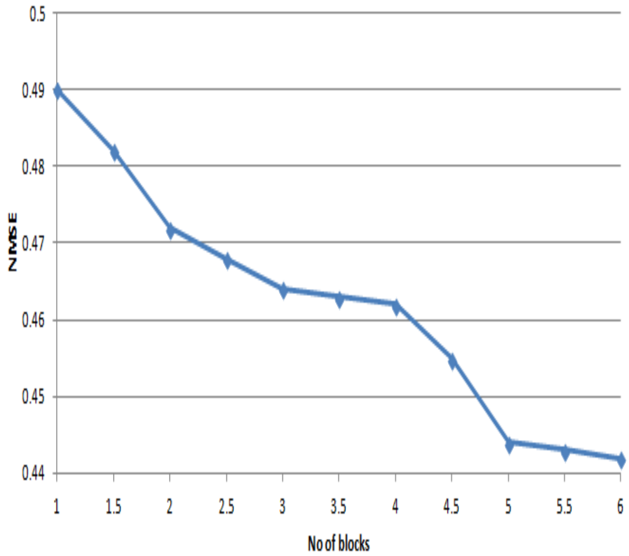

Fig -6: Performance of VBT-SCLD

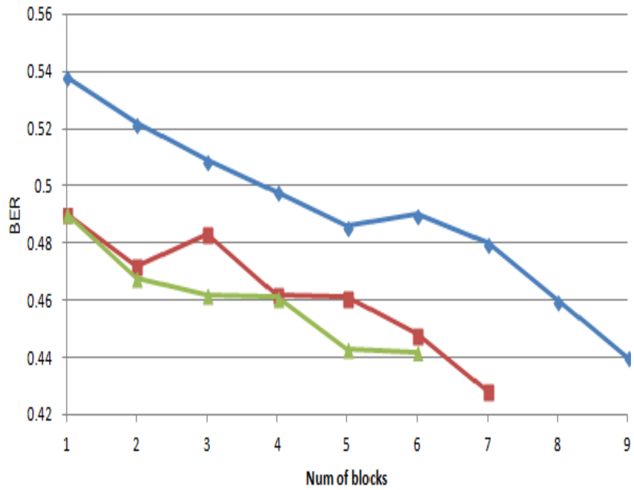

Fig -7: Bit error rate performance

Fig-6 and 7 represents the performance of VBT-SCLD technique. Fig-6 represents the measurement between number of blocks versus Normalised mean square error. VBT-SCLD dynamically change the block size based on the occurance of incoming signal (represent as bits). Next Fig-7 shows the bit error rate for number of blocks. In gragh fig-7 indicates block size 6(green), 7(red), 9(blue).Here taken three block sizes for the comparison measurement

6. CONCLUSIONS

In this paper, the cyclostationarity of general OFDM and SCLD signals affect by a dispersive channel, additive Gaussian noise, phase, and carrier frequency timing offsets are studied. Analytical form expressions for time tomain and frequency domain of cyclostationarity blind parameters have been derived for this digital signal, and their dependence on minimum signal to noise ratio, short sensing times usin BT-SCLD and VBT-SCLD. Here the problems of peak to average power ratios and carrier synchronization in OFDM are analysed. The simulation results shown that the proposed technique results improved the performance enhancement. Finally, we conclude that the block transmission techniques used to reduce aliasing, peak to average power, Bit error rate and alternatively increases the signal to noise ratio.

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