3.2 One Order Cyclostationary Detection

All processes are not periodic function of time but their statistical features indicate periodicities and such processes are called cyclostationary process. In terms of CRNs the PU (primary user) signals which have these periodicities can be easily detected by taking their correlation which tends to enhance their similarity. When we take the fourier transform of the correlated signal results in peak at frequencies which are specific to a signal and searching for these peaks helps in determining the presence of the PU. The peak value is searched in the time domain and compared with the predetermined threshold λ_2. If periodicity is found (peak value $\geq \lambda_2$), it means that the band is used by PU and vice versa. Noise is random in nature and as such there are no such periodicities on taking the correlation. This is the main merit of cyclostationary detection. That is it can differentiate between different types of signals [2],[4].

The probability of detection P_d^C and probability of false alarm P_f^C of one-order cyclo-stationary detection over AWGN channel are approximated as

$$P_d^C = 1-(1-e^{-\frac{\lambda_2^2}{2\delta_A^2}})^L \tag{4}$$

$$P_f^C = 1-[1-Q_1(\frac{\sqrt{2\gamma}}{\delta},\frac{\lambda_2}{\delta_A})]^L \tag{5}$$

where δ^2 is the variance, $\delta_A^2 = \delta^2/(2M_C+1)$ in which M_C is the number of samples for detection, L is the number of diversity branches, γ is instantaneous SNR, $Q_1(.,.)$ is the generalized Marcum Q-function and λ_2 is predetermined threshold.

3.3 Problem Analysis

In this section, we will analyze the sensing performance of our proposed scheme. The overall probability of false alarm and probability of detection of two-stage spectrum sensing scheme [2] are given in (6) and (7)

$$\begin{aligned} P_f &= P_r P_f^E + (1-P_r)P_f^C \\ &= P_r(P_f^E - P_f^C) + P_f^C \end{aligned} \tag{6}$$

$$\begin{aligned} P_d &= P_r P_d^E + (1-P_r)P_d^C \\ &= P_r(P_d^E - P_d^C)P_d^C \end{aligned} \tag{7}$$

where P_r is the probability that a channel would be reported to energy detector as the second stage and therefore, the probability that a channel would be reported to one-order cyclostationary detector will be $1-P_r$. P_r is dependent on SNR of the channels to be sensed and overall P_f and P_d directly depend on *Pr*. For the cooperative spectrum sensing[ ] P_D and P_F can be found to be:

$$P_D = 1-\prod_{i=1}^{N}((1-p_{d_i})(1-p_{e_i})+p_{d_i}p_{e_i}) \tag{8}$$

$$P_F = 1-\prod_{i=1}^{N}((1-p_{f_i})(1-p_{e_i})+p_{f_i}p_{e_i}) \tag{9}$$

3.4 SIC In Transmission Phase

In the cognitive radio (CR) system, power control is a key enabling technique to ensure quality-of-service (QoS) provisioning for primary users (PUs) and secondary users (SUs). How to efficiently allocate power to SUs is not a trivial work, especially, in CDMA based CR systems with successive interference cancellation (SIC) [8], After the hybrid spectrum sensing, if PU's channel is estimated to be idle, SUs access the channel. To improve the system performance and to reduce the multiple access interference we use successive interference canceller (SIC) detector with predefined decoding order at secondary base station. Here the secondary base station under consideration decodes users signals in sequence. Once the kth SU is decoded, the reconstructed signal for this user is removed from the composite signal [1].

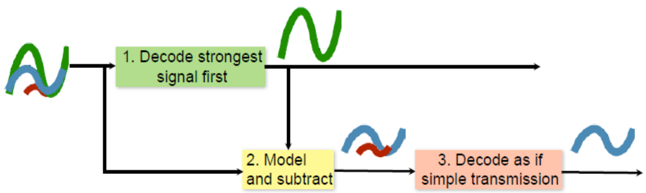


Figure 3: Working of SIC

4. Simulation Results

In this section, we compare our proposed approach of spectrum sensing with the energy detection and the one-order cyclostationary detection. Here N=1000 samples, P_f =0.1 to 0.7. Fig 4.1 gives the idea of performance comparison between HSS and cooperative spectrum sensing. Fig 4.2 (a) & (b) are about effect of sensing parameters on energy consumption. in lower false alarms more channel access chances exist which increase the power consumption while at the same time the required powers to reach the QoS requirements are lower. Also it can be inferred that under fading sensing channel, the optimal false alarm and energy consumption is higher than in AWGN case.

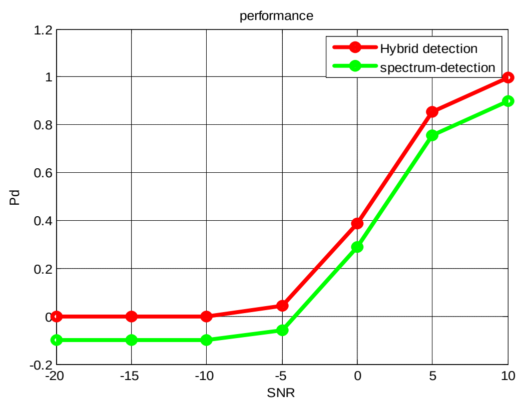
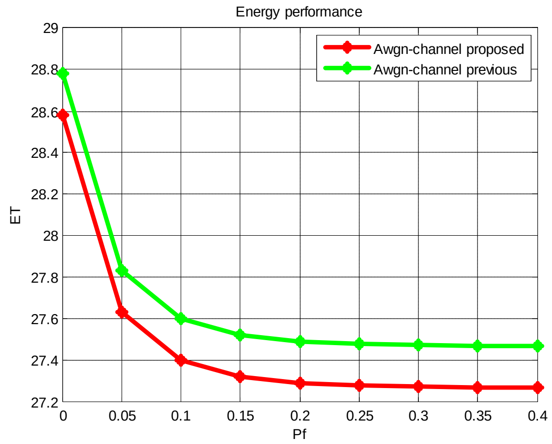
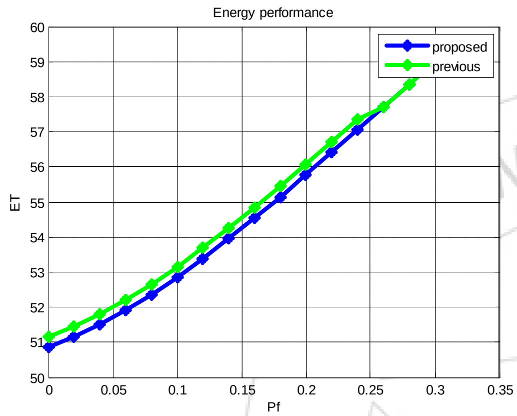


Figure 4.1: Performance comparison between HSS & cooperative spectrum sensing



(a) $\alpha_k = 0.01 bit / sec / HZ$



(b) $\alpha_k = 0.5 bit / sec / HZ$

Figure 4.2: Effect of sensing parameter on energy consumption

Fig 4.3 illustrates the minimum energy consumption per time slot. There are N=3 SUs and two data rates of 0.01bit/sec/HZ and 0.5 bit/sec/HZ is considered. We can see that when the probability of false alarm increases the amount of minimum energy consumption also increases.

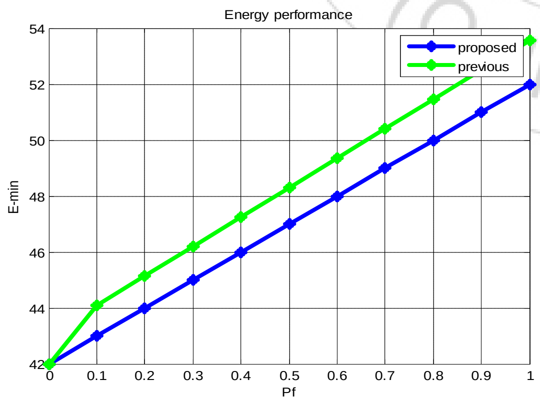


Figure 4.3: Minimum energy performance

Fig 4.4 illustrates the BER v/s SNR of the OFDM system. We know that cooperative spectrum sensing is implemented in CDMA system, where large number of users are present. Accordingly CDMA system has large noise. But this project efficiently decreases the interference and improves the accuracy.

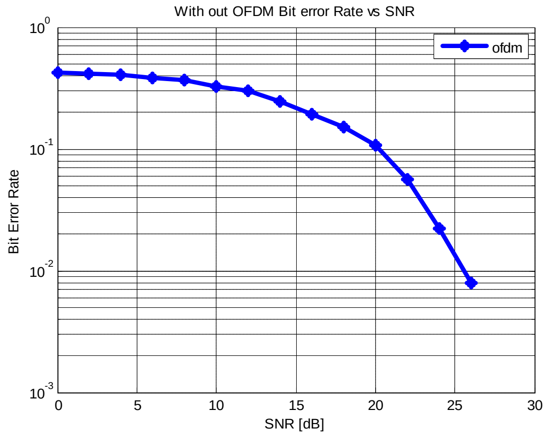


Figure 4.4: Performance of OFDM system

5. Conclusion

Joint optimization using hybrid spectrum sensing is implemented in OFDM system. We know that Hybrid spectrum sensing can increase the spectral efficiency. Two well-known spectrum sensing techniques such as Maximum energy detection (MED) and cyclostationary based detection are used in this project. The two-stage spectrum sensing method urge to achieve better spectrum sensing for cognitive radio at a cost of high computational complexity in low SNR environment. SIC in transmission phase reduces overall interference. Project also compares the performance of hybrid spectrum sensing with cooperative spectrum sensing. From the simulation results we can easily understand the advantage of spectrum sensing.

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Arlin Thomas received the B.Tech degree in Electronics And Communication Engineering from M.G University, Kerala at Mar Baselios Christian College Of Engineering And Technology 2013. And now she is pursuing her M.Tech degree in Communication Engineering under the same university in Mount Zion College of Engineering.