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Signal Diversity Modification Method to Overcome Partial Band Interference in Frequency Hopping Spread Spectrum Communication System

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Abstract- *In this paper, a cost effective solution is proposed to overcome the Partial Band Interference problem in Frequency Hopping Spread Spectrum (FHSS) communication system. The number of Hops per symbol per bit parameter value is modified to develop the cost effective solution. The Bit Error Rate (BER) versus Signal to Noise Ratio (SNR) or $E_b/\mathcal{N}$ plot is taken to analyse the FHSS communication system performance properly in the presence of Partial Band Interference. The entire above spoken FHSS communication system modelling, simulation and performance analysis are implemented and analysed using MATLAB.*

General Terms- *Spread Spectrum Communication System, Digital Communication, Mobile Communication, CDMA et. al.*

Keywords- *FHSS; Partial Band Interference; BFSK; Hop; BER; SNR; MATLAB.*

1. INTRODUCTION

The need for improved performance in spread spectrum communication system transmitter and receiver is of real active interest now-a-days as the application areas for the spread spectrum communication system are increasing day by day because of the well-known practical level advantages of such system. This paper is an approach toward the goal of improving the performance of a Frequency Hopping Spread Spectrum (FHSS) communication system in the presence of Partial Band Interference. Here, it has clearly shown that the performance of an FHSS communication system in presence of Partial Band Interference can be significantly improved by practical result oriented change in the signal diversity or number of Hops per symbol per bit parameter value.

2. FHSS COMMUNICATION IN PRESENCE OF INTERFERENCE

In telecommunications, interference is anything which alters, modifies or disrupts a signal as it travels along a channel between a source and a receiver. With several important application areas in modern telecommunications, such as Wi-Fi and Bluetooth, the importance of FHSS communication is also increasing due to the associated data security with this spread spectrum communication technology. The message spoiling interference matter encountered practically in the FHSS communication system is the Partial Band Interference or Partial Band Jamming.

Therefore, to get the desired system performance, in practice, the elementary objective for the system designer is to reduce the effect of Partial Band Interference. FHSS communication system requires a proper combination of spread spectrum, error control coding, signal diversity and decoding method to perform well in the presence of Partial Band Interference. The performance in the presence of Partial Band Gaussian Noise is measured by the minimum Signal-to-Noise Ratio (SNR) needed for the Bit Error Rate (BER) to be below the desired value. This paper shows the effect of signal diversity for improving the SNR of FHSS communication system in the presence of Partial Band Interference that has the form of Additive White Gaussian Noise (AWGN).

3. SYSTEM DESIGN

To meet the objective, the FHSS communication system in the presence of Partial Band Interference design, simulation and performance analysis are implemented and analyzed in MATLAB. For such system design, Binary Frequency Shift Keying (BFSK) is taken as the Digital Carrier Modulation technique. For detection, the non-coherent M-ary FSK or MFSK detection is used. The jammer jams 1 of the *L* frequency bands when Partial Band Jamming is turned on or off by giving the Partial Band Jamming input 1 or 0 in the MATLAB program. For MATLAB simulation, number of FHSS users is 1; number of data symbols in the simulation is 10000. Under the above criteria, the performance of the FHSS communication system in the presence of Partial Band Interference is observed by changing the value of the number of Hops per symbol per bit with constant value of system Spreading Factor (*L*) parameter as 4.

The value of the number of Hops per symbol per bit parameter, for which, the FHSS communication system in the presence of Partial Band Interference is giving the best cost effective performance toward meeting the analytical BER curve is taken for recommendation as the conclusion from the analysis under other system design parameter considerations. Energy per bit is E_b. AWGN power spectral density is $\mathcal{N}/2$. So, the SNR is $2E_b/\mathcal{N}$. As observed in Fig 1, the above mentioned conclusion is made depending on the BER versus $E_b/\mathcal{N}$ plot from the MATLAB simulation, taking several values of the number of Hops per symbol per bit parameter for the FHSS communication system in the presence of Partial Band Interference under consideration.

Finally, these different conditions are thoroughly compared and checked to suggest the optimum cost effective solution for overcoming the Partial Band Interference in Frequency Hopping Spread Spectrum communication system.

4. SIMULATION RESULTS

Fig 1 shows the performance of the FHSS communication system in the presence of Partial Band Interference with constant value of system Spreading Factor parameter as 4 and varying the number of frequency Hops per symbol per bit parameter by taking its value as 1, 2 and 3. As observed in Fig 1, many numbers of Hops per symbol per bit parameter values are checked in the MATLAB simulation to suggest the optimum cost effective solution for overcoming the Partial Band Interference in the FHSS communication system.

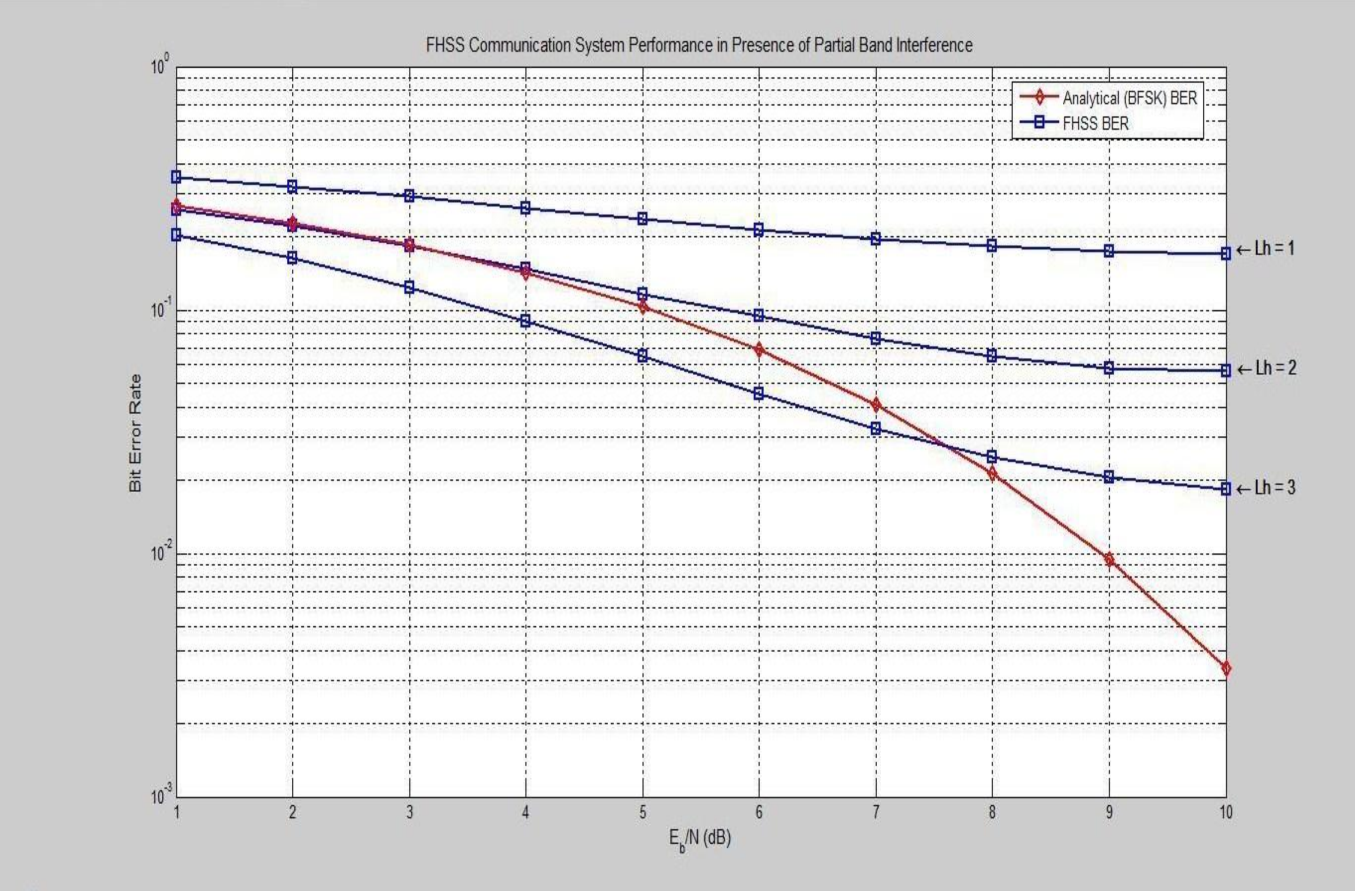

Fig 1: Performance of the FHSS communication system in the presence of Partial Band Interference for different values of number of Hops per symbol per bit parameter & constant value of system Spreading Factor as 4

In Fig 1, the red coloured BER versus $E_b/\mathcal{N}$ curve is the analytical BER that is actually the BER vs. $E_b/\mathcal{N}$ response corresponding to BFSK. The blue coloured curves of BER versus $E_b/\mathcal{N}$ plot are the FHSS communication system BER in the presence of Partial Band Interference with constant value of L as 4 and varying value of number of Hops per symbol per bit (L_h) parameter as 1, 2 and 3. With increasing value of L_h, the blue coloured FHSS BER curves are approaching toward the red coloured analytical BER curve. Such values of the number of Hops per symbol per bit parameter are chosen after rigorous study of the MATLAB simulations for the Frequency Hopping Spread Spectrum communication system in the presence of Partial Band Interference to demonstrate the objective properly. Such number of Hops per symbol per bit parameter values is giving the BER versus $E_b/\mathcal{N}$ curves within a narrow space approaching toward analytical BER curve making easy visual observation and understanding.

5. SYSTEM ANALYSIS

Taking L = 4 and changing the number of Hops per symbol per bit parameter value as 1, 2 and 3 are giving the results as shown in Fig 1. The amount of transition in the Frequency Hopping Spread Spectrum communication system BER curve for the Hop parameter value of 1 to Hop parameter value of 2 is, i. moderate for the $E_b/\mathcal{N}$ value from 1 to 6 and ii. high for the $E_b/\mathcal{N}$ value from 6 to 10. The BER versus $E_b/\mathcal{N}$ response for the Hop parameter value of 1 is residing above the analytical Bit Error Rate. The BER versus $E_b/\mathcal{N}$ response for the Hop parameter value of 2 is i. same as that of the analytical BER versus $E_b/\mathcal{N}$ response for the $E_b/\mathcal{N}$ value from 1 to 4 and ii. residing above the analytical BER versus $E_b/\mathcal{N}$ response for the $E_b/\mathcal{N}$ value from 4 to 10. The amount of transition in the FHSS BER curve for the Hop parameter value of 2 to Hop parameter value of 3 is, i. moderate for the $E_b/\mathcal{N}$ value from 1 to 6 and ii. high for the $E_b/\mathcal{N}$ value from 6 to 10. The BER versus $E_b/\mathcal{N}$ curve corresponding to the Hop parameter value of 3 has, i. small transition in the BER from that of the analytical BER versus $E_b/\mathcal{N}$ curve for the $E_b/\mathcal{N}$ value from 1 to 9 and ii. moderate transition in the BER from that of the analytical BER versus $E_b/\mathcal{N}$ curve for the $E_b/\mathcal{N}$ value from 9 to 10. In the presence of Partial Band Interference, the number of Hops per symbol per bit parameter value of 3 is almost closely approximating the desired BER versus $E_b/\mathcal{N}$ response of the analytical Bit Error Rate among all the Frequency Hopping Spread Spectrum simulated Bit Error Rate responses. So, the number of Hops per symbol per bit parameter value of 3 can be taken as a cost effective solution from engineering perspectives to meet the objective. For eliminating the associated additional design complexity, the number of Hops per symbol per bit parameter value of 4 and above is not taken to meet the objective of overcoming the Partial Band Interference in Frequency Hopping Spread Spectrum communication system.

6. CONCLUSIONS

It can be concluded that the number of Hops per symbol per bit parameter value can be changed to the desired level for achieving the required FHSS communication system performance in the presence of Partial Band Interference. It has found that the suitable system design from engineering cost effective viewpoint can be achieved with proper choice of the number of Hops per symbol per bit parameter value considering other system design parameters for a particular FHSS communication system in the presence of Partial Band Interference. So, a well-balanced combination of the number of Hops per symbol per bit and system complexity must be taken by the designer in Signal Diversity modification method for overcoming the Partial Band Interference in FHSS communication system.
Additionally, it has observed in Fig 1, that, the BER versus $E_b/\mathcal{N}$ curve for L_h = 3 is giving the optimum cost effective solution. So, from the above analysis, it can be concluded that the suitable system design from engineering cost effective viewpoint can be achieved by choosing L_h = 3 for a given FHSS communication system in the presence of Partial Band Interference.

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