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DS-SS Turbo Receiver for Reducing BER

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***Abstract*-A turbo receiver for direct sequence spread spectrum(DS-SS) is proposed,where parity bit selected code is employed. Detection and decoding are performed iteratively for each detected bit.Linear block encoders are used to generate parity bits which selects spreading codefrom the setof orthogonalspreading sequences.Significant reduction in BER is observed in AWGN channel when a turbo receiver is used in these system.**

Index terms- Turbo receiver, spread spectrum communication, bit error rate(BER.)

1. INTRODUCTION

Systematic block codes append parity to end of block of information bits.Limited number of errors can be corrected at receiver end [1,2].In direct sequence spread spectrum systems,spreading sequence is used to spread information over large bandwidth.If this parity bits are used to select spreading codes from a set of orthogonal spreading sequence then the probability that receiver incorrectly identifies the correct spreading sequence is highly unlikely[3].To obtain all benefits of SS-PB system.In the transmitter the convolutionally encoded & interleaved data bits are used as input to parity bit calculator whose output then selects the spreading code to be used to spread data block. The receiver implements the turbo processing by iteratively exchanging soft information of coded bits between soft input soft output (SISO) detector & SISO decoder[4].The likelihood of each detected bits in terms of log likelihood ratio(LLR) is calculated by using extrinsic information provided by SISO decoder in last iteration.This soft information is then used as input for SISO decoder in next iteration.Simulation result shown in this paper shows a significant improvement in performance of SS-PB system,when turbo receiver is implemented.

The rest of paper organized as follows. Model transmitter is explained in section 2, section 3 describes Turbo receiver, simulation results are described in section 4, and lastly conclusion is derived in section 5.

2. MODEL TRANSMITTER

Coded spread spectrum is considered where information bits are convolutionally encoded,after passing through interleaver inputted to SS-PB systems.Each information block is input to parity bit calculator.The parity bits of parity vector p are found by multiplying the information vector and the parity matrix.

p=mP

Where P is the parity matrix part of generator matrix of systematic code G=[I/P].I is a k × k identity matrix.

The parity bits are input to the spreading sequence selector which outputs the antipodal sequence $c_i(t)$ where i is the decimal representation of p.The unique set spreading sequence allotted to transmitter is made up of orthogonal sequence.In other words:

$$\int_{jTb}^{(j+1)Tb} c_i(t)c_m(t)dt = 0 \; for \; i \neq m$$

The information is moduled using binary phase shift keying(BPSK) then BPSK signal is multiplied by the spreading code. On the interval $jT_b \leq t \leq (j+1)Tb$,the transmitted signal is:

$$s(t) = b_j A c_i(t) cos2\pi fct. \qquad (1)$$

Where j=0,1...(k-1),bj=$2m_j$-1,f_c and A are frequency and carrier amplitude respectively and $c_i(t)$ is code selected by parity bits.

After transmission through the channel, the received signal is r(t) = α(t)s(t) + n(t), where α(t) is the fading amplitudeand n(t) is a zero-mean white Gaussian noise process withpower spectral density of N0/2 .

To be able to determine which spreading code is used in thetransmitter, the receiver is equipped with Q matched filters,each matched to one of the spreading codes of set {c_q (t)}. Theoutput of the q^{th} matched filter on the jth signalling intervalis:

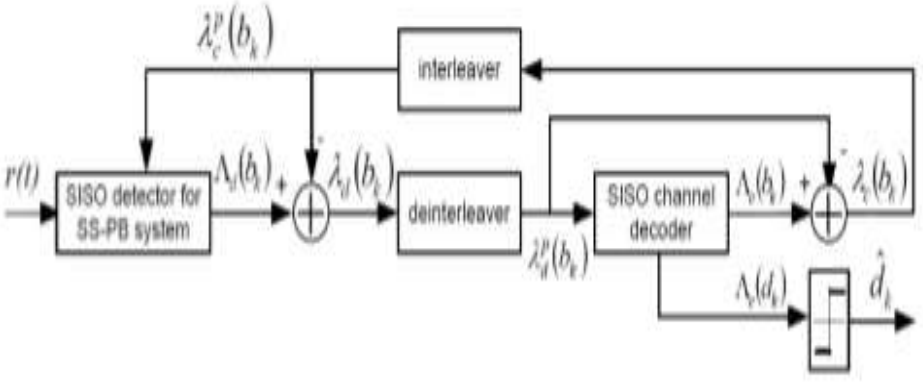


Fig. 1. Proposed turbo receiver for spread spectrum systems employing parity bit selected spreading codes.

$$Z_q[j] = \begin{cases} \alpha[j]b[j]AT_b + n_q[j] & if\ c_q(t)\ is\ used \\ n_q[j] & else \end{cases} \qquad (2)$$

Where $n_q[j]$ is qth matched filters response to the input noise on the jth signalling interval and has Gaussian distribution.As the filters are matched to orthogonal spreading codes,uncorrelated noise output samples are obtained.We are assuming a frequency non-selective slowly varying fading channel,where the fading amplitude remains constant over one bit interval.

3.TURBO RECEIVER

Figure 1 shows the turbo receiver.The SISO detector specially designed for SS-PB systems and SISO channel decoder are the two stages that are connected by interleave and a deinterleaver.The SISO detector observes the matched filters output and by considering the extrinsic information provided by the SISO channel decoder in previous iteration, delivers the aposteriori LLR of transmitted “+1” and a transmitted “-1” for each coded bit Using Bay’s rule we get the equation:

$$\Lambda_d(b_k) = \ln\frac{P(r(t)|b_k=+1)}{P(r(t)|b_k=-1)} + \ln\frac{P(b_k=+1)}{P(b_k=-1)} \qquad (3)$$

Where the term denoted by$\lambda_c^p(b_k)$,represents the a priori LLR of the coded bit $b_k$calculated by the SISO channel decoder in the previous iteration.

The first term denoted by$\lambda_d(b_k)$,represents the extrinsic information provided by the SISO detector about the kth coded bit,b_k.

This extrinsic information iscalculated by the SISO detector based on the matched filters output.This extrinsic information is then passed through deinterleaver and is taken as apriori information by decoder in next iteration.The priori information generated by detector and trellis structure of convolutional code helps channel decoder to calculate the a posteriori LLR of each coded bit.

The SISO channel decoder discussed here provides a posteriori information for both coded and data bits is based on the algorithm which is the slight modification of BCJR algorithm [5].

The extrinsic information delivered by the SISO detector $\lambda_d(b_k)$ can be written as

$$\lambda_d(b_k) = \ln\frac{P(r(t)|b_k = +1)}{P(r(t)|b_k = -1)}$$

$$= \ln\frac{\sum_{b\in B_+^k} P(Z|b)\prod_{l\neq k} P(b_l)}{\sum_{b\in B_-^k} P(Z|b)\prod_{l\neq k} P(b_l)} \qquad (4)$$

Where P(b_l) is the probability that the lth bit equals to b_l for $b_l \in \{+1,-1\}$,and Z is a Q × k_0 matrix which represents output of Qth matched filter overk_0th signaling interval.

If Y is the matrix representing output of Q matched filter which is noise and fading free over $k_0$signalling interval when b is send,and v is the index of spreading code selected by b.in otherwords,

$$y_{ql} = \begin{cases} b_l AT_b & if \quad q = v \\ 0 & otherwise \end{cases} \qquad (5)$$

Where y_{ql} is the qth noise free matched filter output in lth signaling interval.The apriori probabilities in (4) can be calculated based on their LLR’s $\lambda_c^p(b_k)$ as follows[5].

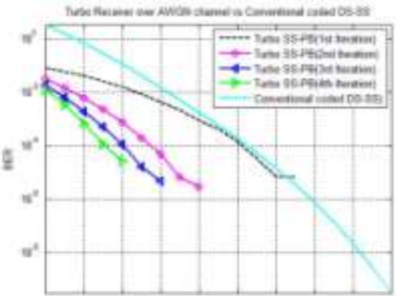
$$P(b_{l)} = \frac{\exp(b_l\lambda_c^p(b_l))}{(1+\exp(b_l\lambda_c^p(b_l))} \qquad (6)$$

$$= \frac{1}{2}\left[1 + b_l \tanh\left(\frac{1}{2}\lambda_c^p(b_l)\right)\right] \qquad (7)$$

Using equation (7),extrinsic LLR$\lambda_d(b_k)$ can be calculated after passing it through a deinterleaver whose output is nothing but apriori information for SISO channel decoder.The extrinsic LLRs $\lambda_c(b_k)$ at the output of channel decoder are formed by substracting the apriori LLRs $\lambda_d^p(b_k)$from the a posteriori LLRs of the coded bits$\Lambda_c(b_k)$.A posteriori LLRs of the data bits are used to make decision on data bits in last iteration.

4 SIMULATION RESULT

The simulation is performed, the design is based on the linear (10,6) block encoder as explained in [3].The BER performance of proposed turbo receiver in AWGN channel for the coded PB-SS system based on the (10,6) block encoder along with conventionally coded DS-SS system is shown in figure 2.The simulation result shows a significant performance improvement over multiple iterations.



5 CONCLUSION

Turbo receiver for DS-SS system is proposed, algorithm for SISO detector is developed in which the LLRs of each bit is calculated depending upon the received signal.The proposed turbo receiver consists of SISO detector and SISO channel decoder.Iteration of LLRs between these two components provides significant improvement in BER without sacrificing the spectral efficiency.If SS-PB system is used in multiuser scenario,the improved BER performance of the proposed system can traded off against additional users in code division multiple access (CDMA) system.

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