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Performance in Channel Coding with OFDM System

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Abstract: The evaluation of bit error rate (BER) performance for various two or three dimensional turbo product codes (TPCs) is discussed. The turbo product code decoder is implemented using hard input hard output data, which is impaired by additive white Gaussian noise (AWGN).The effectiveness of the iterative TPC BER is evaluated using non sequential/ sequential decoding. OFDM is a suitable candidate for high performance of wireless communication systems. The use of turbo product coding and power allocation in OFDM is useful to the desired performance at higher data rates. Simulation coding is done over additive white Gaussian noise (AWGN) and impulsive noise (which is produced in broadband transmission) channels.

The simulation results of estimated Bit error rate (BER) show that the implementation of BCH code with the under BPSK ,QPSK and QAM modulation technique is highly effective to combat inherent interference in the communication system.

Key Words*:* BER, eBCH, TPC, OFDM, ISI, CSI, SISO, HDD.

1. INTRODUCTION

Turbo error correction coding is a powerful channel coding scheme used for power limited systems such as deep space wireless communications systems. Turbo codes offer a performance closer to the Shannon limit than any other class of error correcting codes [1]. Turbo product codes (TPCs) are also known as a block turbo codes, that has an excellent performance at high code rates and can provide a wide range of block sizes [2]-[3]. TPCs can be constructed using two or simpler linear codes either serially or in parallel; in order to achieve acceptable error performance with manageable encoding and decoding complexity. To achieve the ultimate gain of TPCs, the decoder has to take soft input and produce soft output, and hence it is called soft input soft output (SISO) decoder. The soft decoding is based on the Chase II algorithm that requires a large number of hard decision decoding (HDD) operations for each row/column in the received matrix. Moreover, the Chase II algorithm produces hard data which has to be converted to soft information before it can be utilized by the soft input decoder in the subsequent iterations. The large number of HDD performed by the Chase II algorithm and the hard to soft data conversion considerably increases the decoder computational complexity and delay. Furthermore, the computation of the log-likelihood ratios (LLRs) of the received bits, requires accurate knowledge of the channel state information (CSI). In the absence of LLR knowledge, the coding gain promised by SISO TPCs will not be attained. Consequently, hard input hard output (HIHO) decoders have been proposed for applications where low complexity and short delay are required[4]-[5].which reduces the number of required SISO iterations by replacing part of the SISO iterations with a number of hard input hard-output (HIHO) iterations. This method has reduced the overall number of HDD operations by 20% and the number of arithmetic operations by 35%.

2. TURBO PRODUCT CODES

TPCs are multidimensional arrays constructed from two or more linear block codes denoted as the component codes. Two dimensional TPCs are the most common among other TPCs where the product code is obtained using two systematic linear block codes min are the codeword size, number of information bits and minimum Hamming distance, respectively. As depicted in Figure 1, the TPC is constructed as follows: a two-dimensional product code is built from two component codes with parameters C 1 (n 1, k1, d1) and C2 (n2, k2, d2), where ni, ki, di indicate code word length, number of information bits, and minimum hamming distance respectively [3].The product code P = C1 x C2 is obtained by placing (K1 x K2) information bits in an array of K1 rows and K2 columns. The parameters of product code P are n =n1 X n2, K=K1 x K2, d=d1 x d2 and code rate is R = R1x R2, where Ri is the code rate of Ci, Thus long block codes are built with large minimum Hamming distance. Figure 1 shows the procedure for construction of a 2D product code using two block codes C1 and C2. The rows of matrix P are the code words of C1. The columns of matrix P are code words of C2 [3].

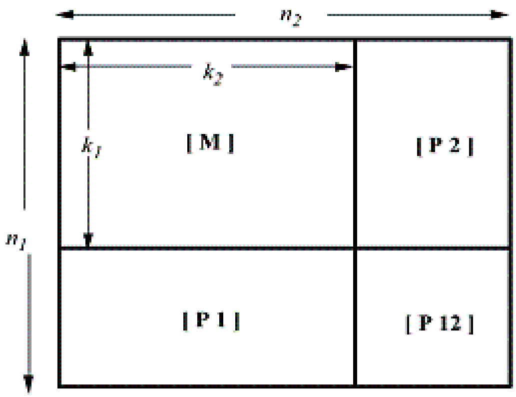

Figure 1: 2D product code constructed using two component codes

3. Block turbo coded OFDM system using channel

The transmitter configuration for the block turbo coded OFDM system is shown in Figure 2

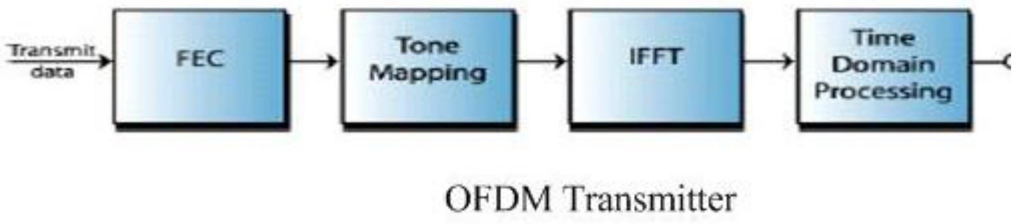

Figure 2: Transmitter configuration for the block turbo coded OFDM system

The block turbo code encoding, comprises of total K x K information bits that are placed into a k x k array. The a single parity check code is applied to every row of the array to result in a k x n matrix and subsequently the same code is applied to each column of the resultant matrix to yield an n x n matrix. The block turbo coded bits are mapped into complex numbers representing QPSK, 16-QAM and 64-QAM constellation points. The stream of complex valued sub-carrier modulation symbols at the output of the mapper is divided into groups of 48 complex numbers. Each group is transmitted in an OFDM symbol with 4 pilot carriers added. Thus, each symbol is constituted by a set of 52 carriers. 12 pilot carriers that are padded with zeros to make the number of subcarriers per symbol a power of 2 and applied to a 64- point IFFT which performs the OFDM modulation. The guard interval is inserted at the transition between successive symbols to absorb the intersymbol interference (ISI) created by multipath in the channel.

Figure 3 depicts the receiver configuration for block turbo coded OFDM system. The assumption is that the OFDM symbol synchronization is accomplished, the symbol cyclic prefix or guard interval are then removed and the useful portions of the OFDM data symbols are fed into a 64-point FFT which performs the OFDM demodulation.

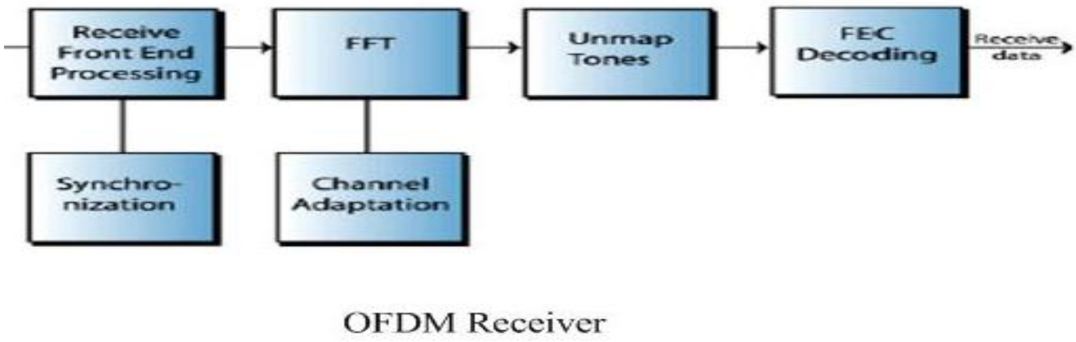

Figure 3: Receiver configurations for the Block turbo code OFDM system

The symbols at the output of FFT are used in channel estimation block. The channel estimation block estimates the channel impulse response by comparing the received training symbols with the known training symbols. The equalization block corrects the channel distortion by dividing the data carriers using estimated channel response determined in the channel estimation block. The equalized symbols are fed into a soft decision calculation block, which pass the soft input values to the iterative decoding block for turbo product code.

The conventional receiver operations, when the received soft input [R] enters into soft-in-soft-out (SISO) decoder for block turbo codes, the first thing that the decoder has to do is to search p least reliable position which is distorted severely by the channel. Based upon how accurately we find the p least reliable position, the error correction capability of the block turbo code will be varied. For conventional receiver operation the received symbols went through the equalization block where compensates for the distortion created by multipath in the channel. Due to such compensation being done by equalizer, it might cause the decoder not to find weak points, which can lead to lower the error correction capability of the block turbo code. Since it is considering coherent demodulation and not the system without having channel estimation equalization blocks. As a method of finding the parts distorted by the channel as weak points, it is come up with the scheme applying channel state information (CSI) to the soft input value so that the modified soft input at the input of the iterative decoder can be defined as,

$$\mathbf{R'=CSI\,.\,R} \qquad (1)$$

Replace R in R’, all equations are held in themselves. Particularly, equation is written like this

$$\mathrm{r}_{\mathrm{j}}' = \frac{CSI.R-c^{c}\ \hat{}2-|CSI.R-c^{d}|\hat{}2}{4}\ c_j^d \qquad (2)$$

TPC code (Hamming code as constituent code) with number of iteration has been tested in an AWGN channel.
The iterative decoding of product codes is also known as block turbo code(BTC)because the concept is quite similar to turbo codes based on iterative decoding of concatenated recursive convolutional code.
TPC (eBCH) (127,120,1) with code rate of 0.87 and 3rd iteration in a AWGN channel provides a BER of 10^{-7} at an Eb/No.

4.BER performance of Turbo Product Code under AWGN channel

The BER performance of turbo product code under AWGN channel for different iterations. From the result obtained it is observed that, with increase in the number of iteration, increases BER performance improving using chase algorithm. In closed chain error pattern algorithm using single iteration it will decodes all rows/columns, giving better BER performance.

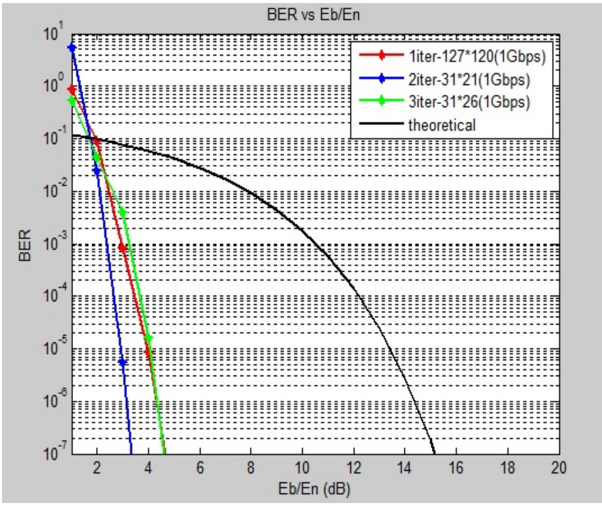

Figure 4: BER performance of block turbo coded 16 QAM-OFDM modulations

The Figure.4 shows that BER versus Eb/No over AWGN channels for the TPCs $(127, 120, 1)^2$, $(31, 26, 1)^2$ and $(31, 21, 1)^2$. Obviously, these codes have similar code sizes (4 to 1800 bytes) and different code rates that are equal to 0.87, 0.65 and 0.51, respectively. It can be noted from this Figure. 4, that the coding gain advantage of the non sequential HIHO decoder is proportional to the code rate.

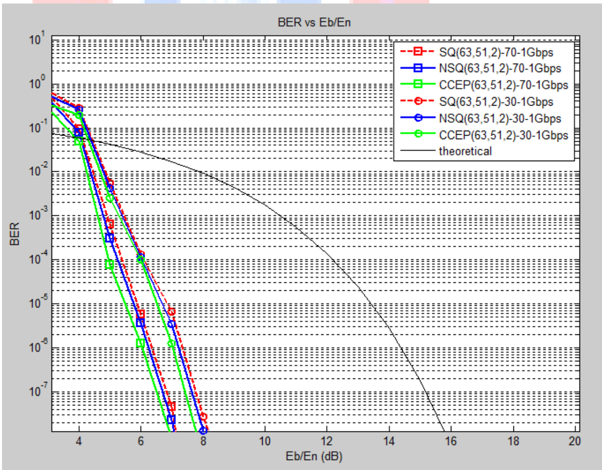

Figure 5 The BER vs Eb/No for TPCs with different code size but with the same code rates over AWGN channels.

Analysis of TPC (eBCH) is done considering parameters like BER versus E_b/N_0 ratio, characteristics of channel under consideration, noise variance of channel etc.

5. Results and Conclusion

The BER performance of various TPCs with different code sizes and code rates ~ 0.5 & 0.35 over AWGN channel is represented in Figure 5.The BER performance measured upto 10^{-7} for TPC under an AWGN channel is observed that data rates transmission is up to 1 Gbps for 3rd iterations. It is noted from this Figure 4 that extra coding gain offered by the non sequential is inversely proportional to the code size. After comparisons result, it is concluded that the decoding method is more useful as compared to other decoding technique. Conclude it is more efficient as compare to other algorithm; get better result and BER versus Eb/No.The effect of TPC (eBCH) channel coding method is evaluated using AWGN channel in OFDM mode. Implementing IEEE 802.16 system along with method to reduce the number of TPCs decoded in the closed chain error pattern algorithm for TPCs constructed with multi-error-correcting extended eBCH codes is expected to provide a better performance with respect to data rate, bandwidth and power gain, as compared to other available decoding techniques.

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