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QPSK with LDPC Codes and its Performance near Shannon's Limit

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Abstract - **Digital video broadcasting (DVB) standards started a search for more efficient transmission technology. It uses QPSK modulation with concatenated convolution and reed soleman codes. In this paper we discuss LDPC codes, a new coding proposal that use higher order modulation with a goal of 30% throughput increases for the same bandwidth and power. A QPSK modulation technique is studied where the coded bits of an irregular LDPC codes are passed directly to a modulator.**

Index Terms: **DVB(Digital video broadcasting), QPSK (Quadrature Phase Shift Keying), LDPC codes(Low Density Parity Check codes).**

1. SHANNON'S LIMIT:

In a remarkable paper published in 1948, Shannon shattered the belief that the performance of communication systems in a noisy environment was limited. He showed by adding redundancy to the information, error induced by a noisy channel can be reduced to any desired level without sacrificing the rate of information transmission, if rate of information is smaller than the channel capacity. He showed that if the redundancy was not used in a noisy controlled environment, error free performance was not possible.[8][16][17]

2. REVIEW OF LDPC CODES:

LDPC codes were discovered by Gallagar in 1962, but they were not given much attention for decades as the technology at the time was not mature for efficient implementation. Motivated by the success of iterative decoding of turbo codes. MacKay and Neal reintroduced LDPC codes in 1995, and generated great interest and activity on the subject. Unlike turbo codes, LDPC codes have an easily parallelizable decoding algorithm which consists of simple operation such as addition, comparison and table look-up. Moreover the degree of parallelism is "adjustable" which makes it easy to trade-off throughput and complexity.

The relative quiescence of the coding field of the coding field was utterly transformed by the introduction of turbo codes, proposed by Berrou ,Glavieux and Thitimajshima in 1993,wherein all the key ingredients of successful error correction codes were replaced. As researchers struggled through the 1990s to understand just why turbo codes worked ,McKay and Neal, introduces a new class of block codes desire to posses many of the features of the new turbo codes It was soon recognized that these block codes as LDPC codes.[1][2][3][4][5]

2.1 OFDM TECHNIQUE:

The principle of OFDM has been around for several decades, through it became a popular technology for commercial digital communication systems only in the last two decades [1]. One of the main advantage of using OFDM is that it facilitates the use of a reduced complexity equalizer. Use of error-correction coding (ECC) and interleaving helps to reduce errors resulting from spectral nulls, commonly found in multipath channels. Furthermore, ECC provides a greater immunity to the effect of multipath and signal clipping due to high signal peak to average power ratio.

As may be seen from [9], a cellular mobile system based on OFDM, which uses pilot based correction could provide a significant improvement in Rayleigh fading environment. The delay spread could cause an intersymbol interference (ISI) when adjacent data symbols overlap and interfere with each other due to different delays on different propagation paths. The maximum Doppler shift in a multicarrier modulated system might cause a significant intercarrier interference (ICI) as the subchannel spacing is quite small, and this ICI may lead to a significant degradation in system performance [12]. The use of channel coding with OFDM will improve the performance significantly. This paper investigates the performance of two different coding systems with OFDM. We coded LDPC and concatenated Reed Solomon convolution code (RS-CC) QPSK-OFDM system in non-line-of-sight (NLOS) multipath fading channel. After performing the frequency domain computation using FFT, and fed to the equalizer .Assuming the delay spread of the channel is smaller than the cyclic prefix and the time variance of the channel per one OFDM symbol is negligible, the received symbol R_k in the frequency domain is given by

$$Rk = H_k A_k + W_k \qquad (1)$$

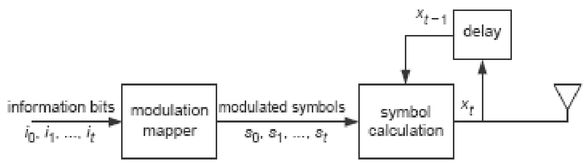
Where, $A_k = a_k + jb_k$ denotes the QPSK symbol, Hk is the frequency-domain gain of the k-th subchhannel, and Wk is the complex additive white Gaussian noise with variance σ^2 per real dimension. The LLR former is then given by

$$\lambda(a_k) = \left(\frac{2|Hk|^2}{\sigma^2}\right) Re(Y_k) \qquad (2)$$

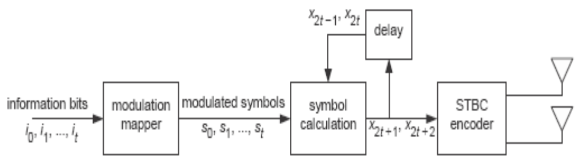
$$\lambda(b_k) = \left(\frac{2|Hk|^2}{\sigma^2}\right) Im(Y_k) \qquad (3)$$

Where $Y_k = R_k/H_k$ is the output of frequency domain equalizer.[6][7][13][15]

3. SYSTEM MODEL:



Figure(1). Simple DPSK modulator for a single-link antenna system



Figure(2). Differential STBC encoder

There exist a number of differential modulation schemes that can be employed in single antenna link system that do not require channel estimators and hence invoked non-coherent detection. One such scheme, depicted in Fig. , is differential phase-shift keying (DPSK).

The input bit sequence i0, i1, i2, it is mapped to generate a modulated symbol sequence s0, s1, s2, ...st where the signal constellation is M-PSK with M signal points. The signal constellation can be represented by

The resulting information is sent in the difference of the phases of two consecutive symbols.

In general, when LDPC coding is used in conjunction with QPSK-OFDM communication system, the formation of the log-likelihood ratios (LLRs) is an important step; we describe this below for QPSK-OFDM communication system. Assuming perfect synchronization receivers exact the prefix.

4. LOW DENSITY PARITY CHECK CODES IMPLEMENTATION

LDPC codes are linear block codes with sparse parity check matrices $H_{(N-K)xN}$, where each block of K information bits are encoded to a codeword size N and rate ½ can be specified by the following parity check matrix.

$$H = \begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Figure(3),H- Matrix

The same code can be equivalently represented by the bipartite (Tanner) graph in figure 4, which connects each check equation (check node) to its participating bits (bit node).

Parity check equations imply that for a valid codeword , modulo-2 sum of adjacent bits of every check node has to be zero.

$$c_1 + c_2 + c_3 + c_5 = 0$$
$$c_1 + c_3 + c_4 + c_6 = 0$$
$$c_1 + c_2 + c_4 + c_7 = 0$$

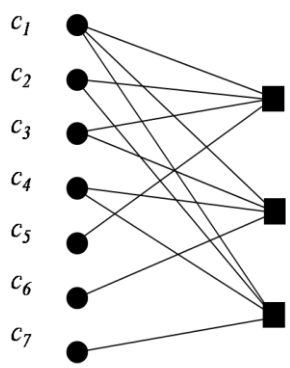


Figure (4), Bipartite graph of an LDPC code

The purpose of the decoder is to determine the transmitted values of the bits. Bit nodes and check nodes communicate with each other to accomplish that. The decoding starts by assigning the received channel value of every bit to all the outgoing edges from the corresponding bit node to its adjacent check nodes. Upon receiving that, check nodes make use of the parity check equations to update the bit node information and sends it back.

RESULT:

Following parameters are consider for simulation in Matlab.

Input bit: 1 0 1, x =1 0 1

Transmitted bit: 1 0 1 1 0 1

Decoding output; 1 0 1

Row=1, column =3, BER=0.5000, n=6, k=3

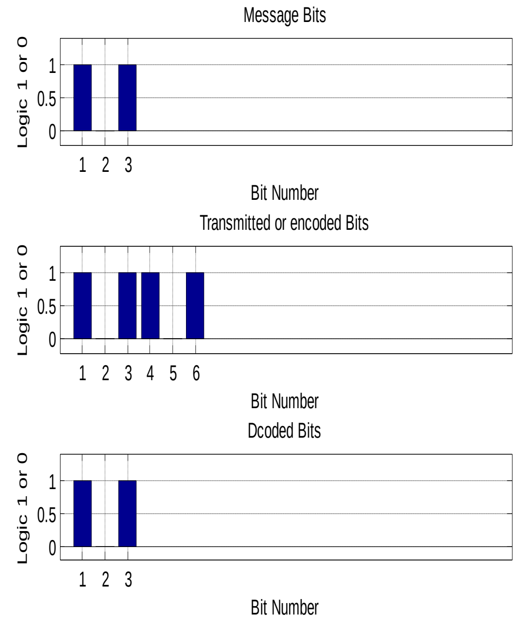


Figure (5)

In figure(6), the bit error graph is plotted and best fitting curve is adjusted by changing the appropriate parameters in matlab programming.

Following parameters are consider for estimation of ber graph.

n =23 , k =12, d min =7

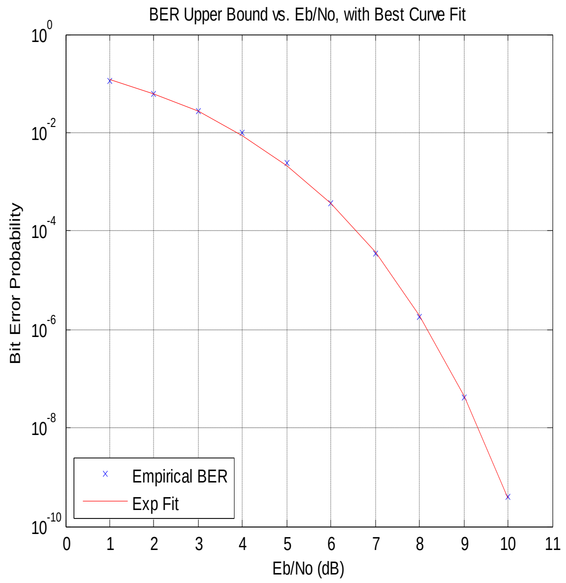


Figure (6) BER graph

CONCLUSION:

The performance of QPSK-OFDM using concatenated Convolution/Reed-Soloman coding system compared with LDPC coded QPSK exhibits better performance.The

Performance of LDPC Ccodes are substantially better than that of other codes, viz ,CC-RS,Turbo codes etc.

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