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Performance Evaluation of DVB System for Text Transfer

Soumyasree Bera and Samarendra Nath Sur

Department of Electronics and Communication, Sikkim Manipal Institute of Technology, Sikkim, India
soumyasree.bera@gmail.com

ABSTRACT

The DVB technology is being used by millions of users across the globe in order to view television (i.e. in satellite communication) by processing the signal generated in one part of the globe by encoding it in multiple layers and sending them on a carrier wave which is being reflected by a satellite which is then received by the antennae at our home. In this paper the same widely proven technology has been re-used for ground based communication. So the authors aim is to test its performance under different channel condition.

Key words: AWGN, BER, Digital Video Broadcasting (DVB), Low-Density Parity-Check (LDPC), Bose-Chaudhuri- Hocquenghem (BCH), Variable Coding and Modulation (VCM)

INTRODUCTION

Digital Video Broadcasting (DVB) is being adopted as the standard for digital television in many countries. The DVB standard offers many advantages over the previous analogue standards and has enabled television to make a major step forwards in terms of its technology.

The system is structured as a toolkit to allow the implementation of the following satellite applications: TV and sound broadcasting, interactivity (i.e., Internet access), and professional services, such as TV contribution links and digital satellite news gathering. It has been specified around three concepts: best transmission performance approaching the Shannon limit, total flexibility, and reasonable receiver complexity [1]. The framing structure allows for maximum flexibility in a versatile system and also synchronization in worst case configurations (low signal-to-noise ratios). Adaptive coding and modulation, when used in one-to-one links, then allows optimization of the transmission parameters for each individual user, dependent on path conditions. In satellite communication, rain attenuation is a very common problem hence such problems are analysed in a simplified scenario and it is shown to achieve a very effective solution for the minimum data-rate/availability requirement; at the same time, it preserves the ACM (Adaptive Coding and Modulation) characteristic feature of offering increased capacity on a best-effort basis. The proposed approach makes the Ka-band spectrum fully available for broadband satellite applications and network-centric systems [2]. Also the application of Low-Density Parity-Check (LDPC) can provide 2.9dB coding gain compared with Convolution Code at a BER of 10-4. It is show that LDPC codes in Ka band are effective and feasible. It can be extended for other systems such as terrestrial communications, geostationary satellite and also for any other mobile links [3].

System Modeling

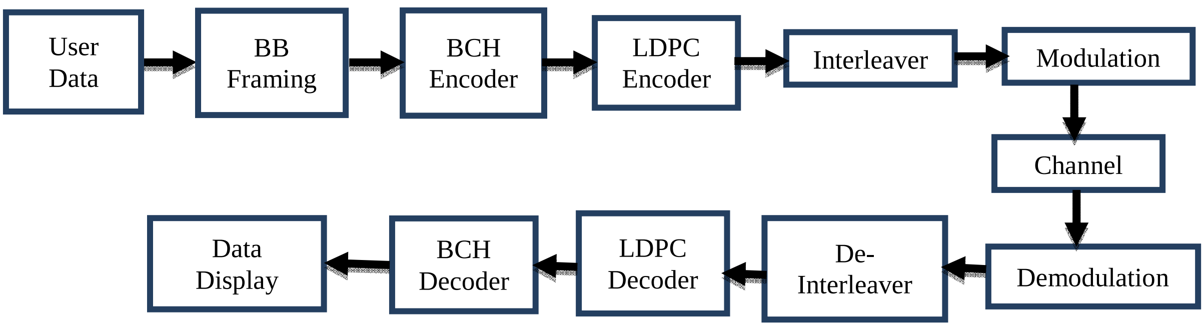

Fig. 1 Block Diagram of the system

Fig 1 shows the block diagram of DVB system designed. It uses two level of encoding: Bose-Chaudhuri-Hocquenghem (BCH) encoding followed by LDPC encoding that gives robustness to the system from the channel impairment with varying code rate. The system even uses variable modulator: QPSK, 8PSK depending on the channel estimation. So the next the important blocks are discussed:

Low-density parity-check (LDPC) code is a linear error correcting code. LDPC codes are capacity-approaching codes, which means that practical constructions exist that allow the noise threshold to be set very close (or even arbitrarily close on the BEC) to the theoretical maximum (the Shannon limit) for a symmetric memory less channel. LDPC codes were invented by Robert Gallager [4] in his PhD thesis. LDPC [5-7] codes are linear codes obtained from sparse bipartite graphs. Suppose that G is a graph with n left nodes (called message nodes) and r right nodes (called check nodes). The graph gives rise to a linear code of block length n and dimension at least n − r in the following way:

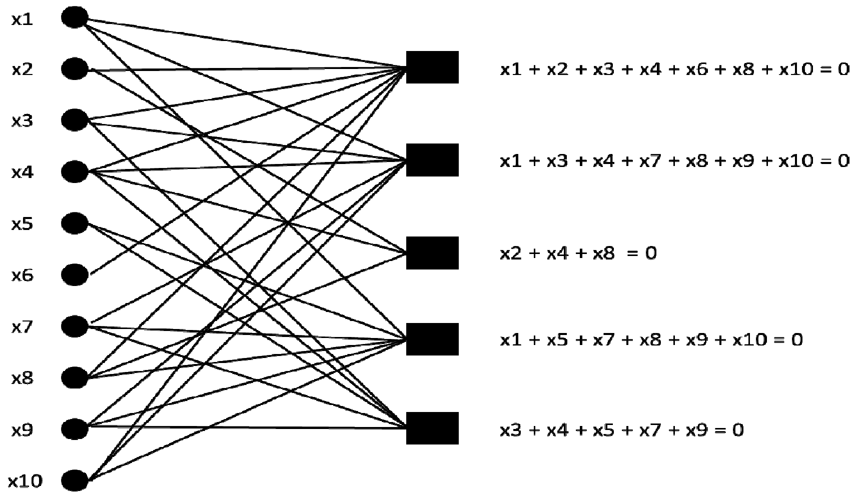

Fig. 2 A LDPC code

The n coordinates of the codeword are associated with the n message nodes. The codewords are those vectors (c_1, . . . , c_n) such that for all check nodes the sum of the neighbouring positions among the message nodes is zero. Let H be a binary r × n-matrix in which the entry (i, j) is 1 if and only if the i^{th} check node is connected to the j^{th} message node in the graph. Then the LDPC code defined by the graph is the set of vectors c = (c_1, . . . , c_n) such that $H*c^T$ = 0. The matrix H is called a parity check matrix for the code. Therefore, any linear code has a representation as a code associated to a bipartite graph (note that this graph is not uniquely defined by the code). However, not every binary linear code has a representation by a sparse bipartite graph. If it does, then the code is called a low-density parity-check (LDPC) code.

The Bose, Chaudhuri, and Hocquenghem (BCH) codes form a large class of powerful random error-correcting cyclic codes. This class of codes is a remarkable generalization of the Hamming code for multiple-error correction. For any positive integers m ≥ 3 and t < 2m−1, there exists a binary BCH code with the following parameters:

Block length:$n = 2m - 1$

Number of parity-check digits: $n - k \leq mt$

Minimum distance: $d_{min} \geq 2t + 1$ (1)

Let α be a primitive element in GF(2m). The generator polynomial g(x) of the t-error-correcting BCH code of length 2m − 1 is the lowest-degree polynomial over GF(2) which has (α, α2, α3, . . . , α2t) as its roots. g(αi) = 0 for 1 ≤ i ≤ 2t and g(x) has α, α2, . . . , α2t and their conjugates as all its roots.
Let φi(x) be the minimal polynomial of αi . Then g(x) must be the least common multiple of φ1(x), φ2(x), . . . , φ2t(x), i.e., $g(x) = LCM\,\{\varphi1(x), \varphi3(x), \ldots\ldots, \varphi2t(x)\}$

•If i is an even integer, it can be expressed as i = i’2l, where i’ is odd and l > 1.
Then αi = (αi’)2l is a conjugate of αi’. Hence, φi(x) = φi’(x).

$$g(x) = LCM\,\{\varphi1(x), \varphi3(x), \ldots\ldots, \varphi2t - 1(x)\} \quad (2)$$

• The degree of g(x) is at most mt. That is, the number of parity-check digits, n − k, of the code is at most equal to mt.
• If t is small, n − k is exactly equal to mt.
• Since α is a primitive element, the BCH codes defined are usually called primitive (or narrow-sense) BCH codes.

CHANNEL MODELLING

AWGN Channel

The relationship between Es/No and Eb/No, both expressed in dB, is as follows:

$$E_S/N_O\ (dB) = E_b/N_O\ (dB) + 10log_{10}(k) \quad (3)$$

where k is the number of information bits per symbol.

Rice Channel

A Rice/ Rician fading channel can be described by two parameters: K and Ω. K is the ratio between the power in the direct path and the power in the other, scattered, paths. Ω is the total power from both paths($\Omega = \nu^2 + 2\sigma^2$), and acts as a scaling factor to the distribution.

The received signal amplitude (not the received signal power) R is then Rice distributed with parameters

$$\nu^2 = \frac{K}{1+K}\Omega \quad \text{and} \quad \sigma^2 = \frac{\Omega}{2(1+K)} \quad (4)$$

The resulting PDF then is:

$$f(x) = \frac{2(K+1)x}{\Omega} e^{\left(-K-\frac{(K+1)x^2}{\Omega}\right)} I_0(2\sqrt{\frac{K(K+1)}{\Omega}}x) \quad (5)$$

where $I_0(.)$ is the 0th order modified Bessel function of the first kind.

$$P_b = 0.5erfc(\sqrt{\frac{k(E_b/N_0)}{(k+E_b/N_0)}}) \quad (6)$$

where P_b is the probability of error; E_b is the energy per bit; N_0 is the noise power.

RESULTS AND DISCUSSION

The authors have simulated the DVB system and tested its performance in twofold:

- BER performance analysis of DBV S2 in AWGN and Rice Channel Condition
- Performance analysis of DBV S2 in AWGN based on the text transmission.

As DVB system includes VCM, hence the system has been analysed for different code rate and modulation techniques.

Performance Analysis

Authors have first tested the designed system under AWGN followed by Multipath Channel condition. The source data in this case is simple form of random data. Under this case, the channel condition is kept fixed and the VCM (Variable Coding and Modulation) scheme of DVB is tested. The fig 3 shows the performance of the system under VCM. As seen that at low SNR QPSK with ½ rate is having the best performance whereas 8PSK with 9/10 has best performance at SNR 9dB.

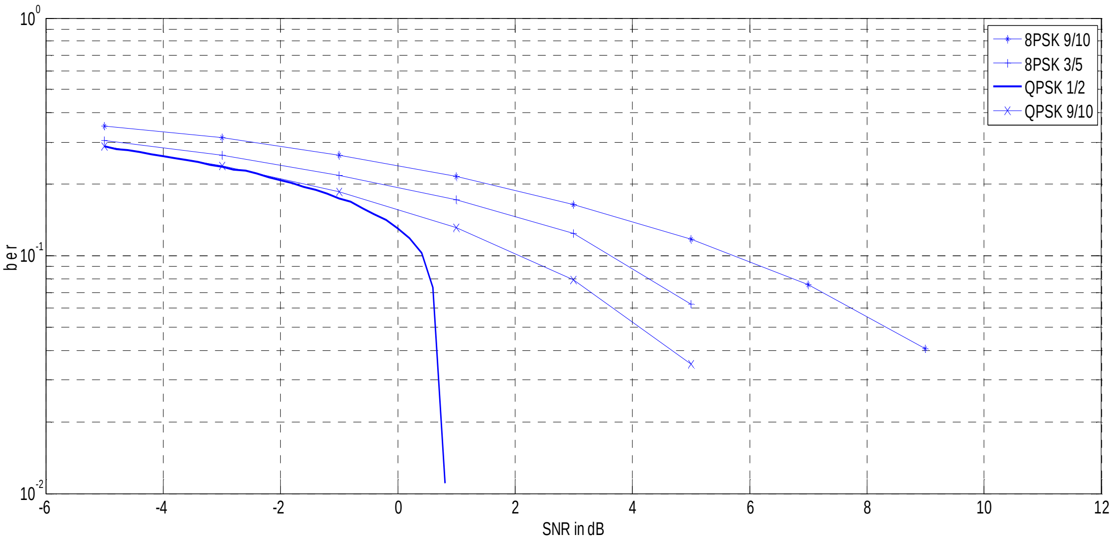

Fig. 3 BER vs SNR performance of DVB system for different modulation and code rate AWGN [8]

Text Transfer

On the completion of the BER performance of the system, the text transfer is been taken up by the authors. The same has been repeated for different SNR and different Channel conditions. The system then is tested for transmission of text. Fig 4 indicates the transmitted and received text that has been transferred under different SNR, Coding and Modulation. At low SNR the received text is nearly same as the transmitted text. This is possible due to the use of LDPC coding that is being used for error correction.

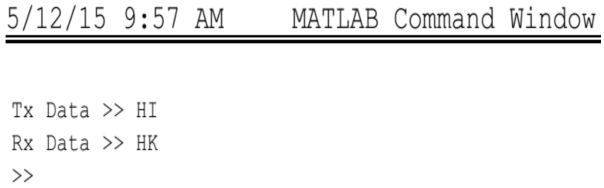

Fig. 4(a) Received Text @ SNR= 3 dB; QPSK 3/4 (AWGN)

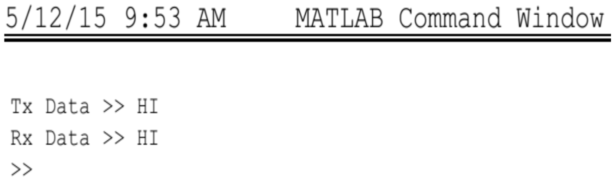

Fig. 4(b) Received Text @ SNR=10dB QPSK 3/4 (AWGN)

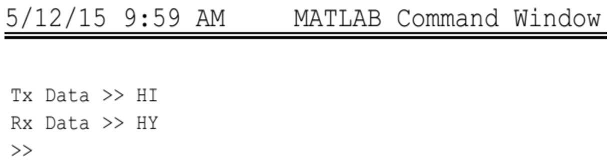

Fig. 4(c) Received Text @ SNR=0dB; QPSK 1/2 (AWGN)

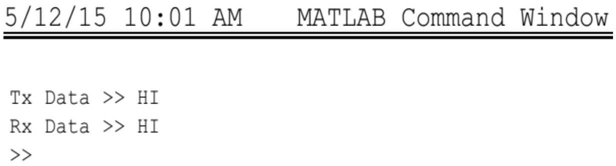

Fig. 4(d) Received Text @ SNR=3dB; QPSK 1/2 (AWGN)

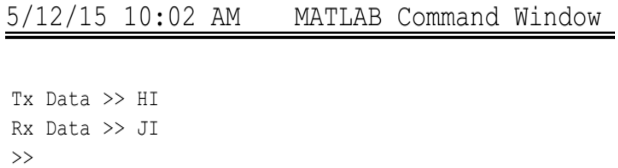

Fig. 4(e) Received text @ SNR= 8dB; 8PSK 9/10 (AWGN)

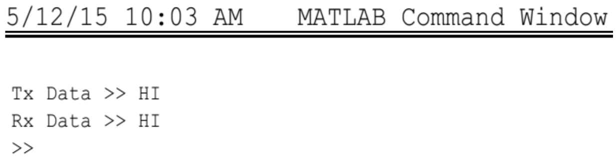

Fig. 4(f) Received text @SNR= 10dB; 8PSK 9/10 (AWGN)

CONCLUSION

DVB technology is widely used technique but limited to satellite communication till date. The same can be extended for ground based wireless communication and it shows a promising result towards this effort. The use of LDPC code plays a greatly under low SNR condition. Also the use of higher modulation technique leads the system capacity closure to the Shannon’s limit. Authors have used the same system to transfer text under different channel conditions. AWGN channel is giving the best performance. Also the same system can be further updated for audio and real time communication which will impose more complexity and also the system has to be tested for more realistic channel condition using further higher modulation like APSK.

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