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Multimedia Communication using DVB technology over Open Range

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Abstract

The DVB technology is being used by millions of users across the globe in order to view television. This technology, processes 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. The same widely proven technology may be re-used for ground based communication for its improvement which still has various limitations. Hence, in this paper,the development of a local open range communication system using DVB is being proposed in order to setup a communication link between two distant places.

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*Keywords:*DVB; BCH;LDPC;BER;QPSK;8PSK;DTMF;AWGN

1. Introduction:

Digital Video Broadcasting(DVB) is a widely accepted and well proven digital televisionbroadcast technology that offers high quality television rather than its analogue counterpart. It has also taken television to a major step forwards in terms of its technology.This achievement has been possible due to the advancement made in integrated circuits and digital signal processing.

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DVB system is basically structured for the implementation of the satellite applications like: TV and sound broadcasting, interactivity, professional services and digital satellite news gathering. It has been specified around three concepts [1]: better transmission performance approaching the Shannon limit, total flexibility, and reasonable receiver complexity. Channel coding and modulation are based on more recent developments in the scientific community: low density parity check codes are adopted, combined with QPSK, 8PSKmodulations for the system to work properly on the nonlinear satellite channel [2-3]. The frame is designed in such a way that (as in Fig 3) allows maximum flexibility in low signal-to-noise (SNR) ratios. Another beneficial feature of the DVB system is its adaptation capability both for coding and modulation so as to serve the individual user (for point –to –point link) at its best making the system independent of the channel conditions.

In this paper authors have revisited the same existing technology in order to reuse the same for ground based wireless communication link. Ground based links under various undesired problems of multipath, which may be tackled up to a great extent by the use of channel encoding like low density parity check (LDPC) which is already embedded in the DVB framing. The proposed link will be tested for its BER performance followed by the transmission of multimedia data like: text, audio, etc. Authors have used WARP v2 [4] board developed by Rice university as the basic hardware.

1.1. System Modelling

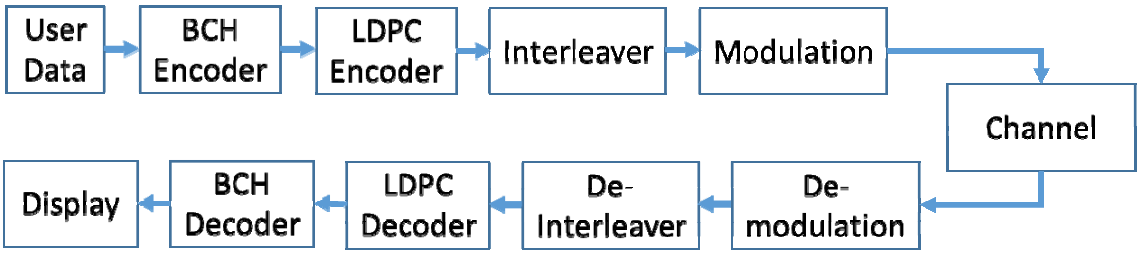

Fig 1: Block Diagram of the system [5]

Fig 1 shows the block diagram of the designed DVB system. It uses two levels 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 next the important blocks are discussed:

1.2. Channel Encoders:

i) BCH CODING :

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. One of the key features of BCH codes is that during code design, there is a precise control over the number of symbol errors correctable in the code. In particular, it is possible to design binary BCH codes that can correct multiple bit errors. Another advantage of BCH codes is the ease with which they can be decoded, namely, via an algebraic method known as syndrome decoding. This simplifies the design of the decoder for these codes, using small, low-power electronic hardware [6-7].

ii) LDPC CODING :

Low-density parity-check (LDPC) code is a lineararror correcting 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 memoryless channel. LDPC codes were invented by Robert Gallager [8] in his PhD thesis. LDPC [9-11] 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:

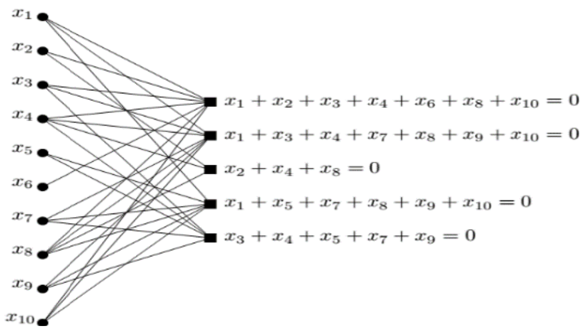

Fig 2: A LDPC code

The n coordinates of the code word are associated with the n message nodes. The code words are those vectors (c1, . . . ,cn) such that for all check nodes the sum of the neighboring 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 ith check node is connected to the jth message node in the graph. Then the LDPC code defined by the graph is the set of vectors c = (c1, . . . ,cn) such that H*cT = 0. The matrix H is called a parity check matrix for the code. Therefore, any linear code has a representation as a code associated with a bipartite graph (note that this graph is not uniquely defined by the code). However, not every binary linear code has a representation of a sparse bipartite graph. If it does, then the code is called a low-density parity-check (LDPC) code.

The input to the LDPC decoder is the log-likelihood ratio (LLR) which is defined by the following equation:

$$L(ci) = log\ (\frac{Pr\ (ci = 0)}{Pr\ (ci = 1)})$$

$$L(ci) = log\ (\frac{Pr\ (ci = 0)}{Pr\ (ci = 1)})$$

(1)

where ci is the ith bit of the transmitted codeword, c. There are three key variables in the algorithm: L(rji) , L(qij) , and L(Qi). L(qij) is initialized as L(qij) = L(ci). For each iteration, update L(rji) , L(qij) and L(Qi) using the following equations

$$L(rji) = 2atanh\ (\prod_{i\epsilon V,\backslash i} tanh\ (\frac{1}{2}\ L(qij)))$$

$$L(qij) = L(ci) + \sum_{j\prime\epsilon Ci\backslash j} L(rji)$$

$$L(Qi) = L(ci) + \ \textstyle\sum_{j\epsilon Ci} L(rj'i)$$

(2)

WhereCi\j andVj\i are index sets.

At the end of each iteration, L (Qi) provides an updated estimate of the a posteriori log-likelihood ratio for the transmitted bit.The soft-decision output for ci is L (Qi). The hard-decision output for ci is 1 if L (Qi)< 0, and 0 otherwise.

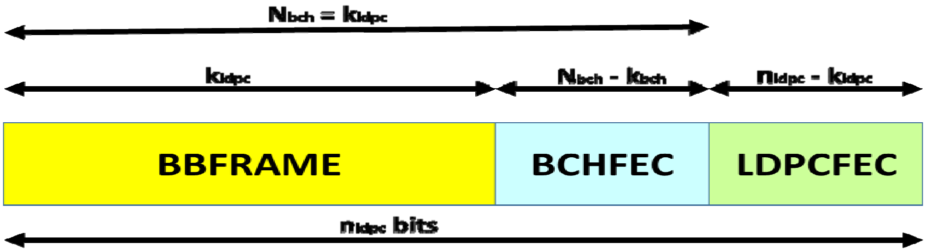

Fig 3: Format of data before bit interleaving (nldpc= 64 800 bits for normal FECFRAME, nldpc= 16 200 bits for short FECFRAME) [1]

1.3. Modulation:[1,12]

Each FECFRAME (which is a sequence of 64 800 bits for normal FECFRAME), shall be serial-to-parallel converted (parallelism level = ηMOD2 for QPSK, 3 for 8PSK,)

Two FECFRAME bits are mapped to a QPSK symbol, i.e. bits 2i and 2i+1 determines the ith QPSK symbol, where i = 0, 1, 2, …, (N/2)-1 and N is the coded LDPC block size.

Bit error rate,

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \tag{3}$$

For 8PSK, the System shall employ conventional Gray-coded 8PSK modulation with absolute mapping (no differential coding).

Bits 3i, 3i+1, 3i+2 of the Interleaver output determine the ith8PSK symbol where i = 0, 1, 2,… (N/3)-1 and N is the coded LDPC block size.

Bit error rate

$$, \quad P_b = \frac{1}{\pi}\int_0^{(M-1)\pi} exp\,(-\frac{kE_b sin^2[\pi/M]}{N_0 \quad {}^2\theta}) \tag{4}$$

2. Hardware Implementation:

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Fig 4 shows the hardware setup for the proposed system. The total system specification is mentioned in table 1. The device that is being used is WARP v2 board which acts as both transmitter and receiver. Fig 5(a) represents the basic procedure followed for performing the experiment.

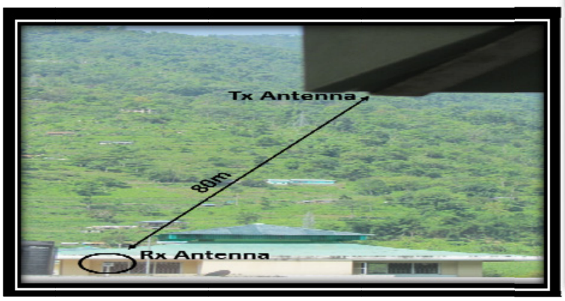
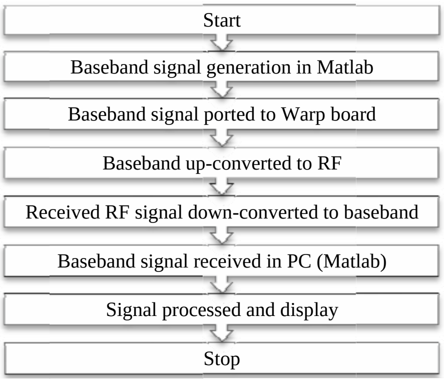


Fig. 4(a): Antenna Setup

Fig. 4(b): Total hardware setup



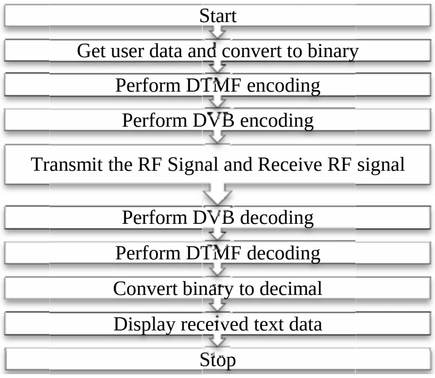


Fig. 5(a): Flowchart for Signal porting.Fig. 5(b): Flowchart of Text transmission with DTMF

Table 1: System Specification

Sl. No.	Parameter	Value
1	Distance	80m
2	RF Frequency	2.462GHz
3	Transmitter Amplifier Gain	15 dB
4	Receiver Radio Frequency gain	30 dB
5	Receiver Baseband Gain	63 dB
6	Antenna beamwidth	20˚
7	Antenna Gain	17 dBi
8	Antenna Polarization	Horizontal
9	Hardware Used	WARP v2 board (Virtex 4)

3. Result & Analysis

a) Bit Error Rate (BER) Analysis:

The system is first tested for its BER performance and followed by the multimedia communication. Multimedia Communication includes communication of tone, actual audio and then followed by text.
System Consideration:

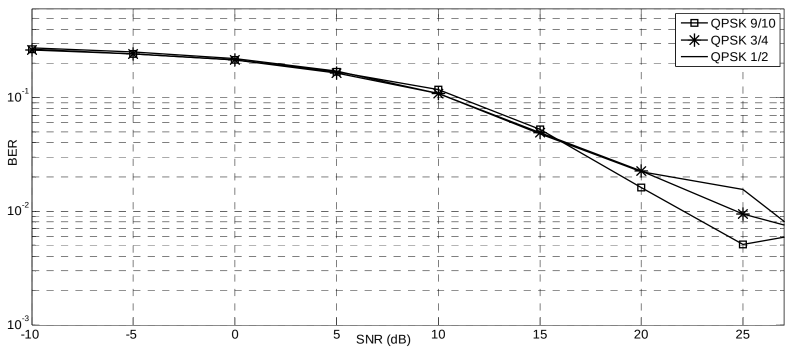


Fig.6: BER vs SNR performance of DVB system under different code rate

In terms of code rate, the system is also tested and verified keeping modulation type constant to QPSK. It can be observed from the Fig 6 that 9/10 has better performance than ½.

b) Multimedia Communication Over Open Range

The developed system after being tested for its BER performance, is tested for multimedia communication capability.

i) Tone Transmission:

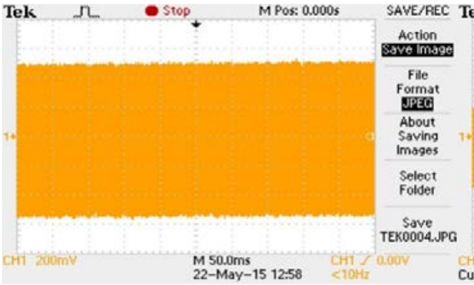


Fig. 7(a):1 KHz tone transmission

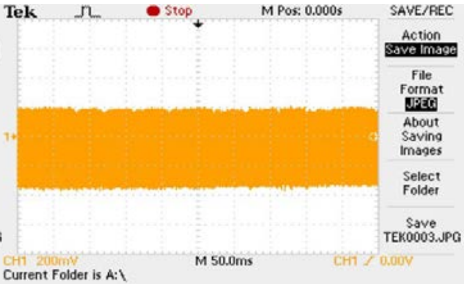


Fig. 7(b): 1 KHz tone reception

ii) Audio Transmission:

Fig. 8(a): Audio Data Transmission

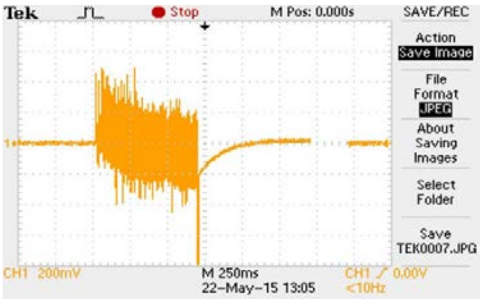


Fig. 8(b): Audio Data reception

iii) Text Data Transmission:

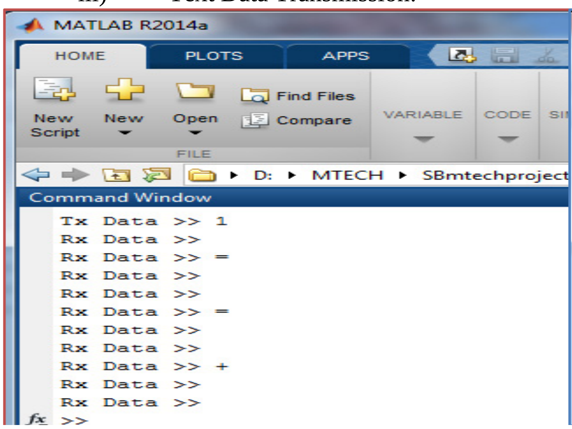


Fig. 9(a): Text Data reception with DVB only

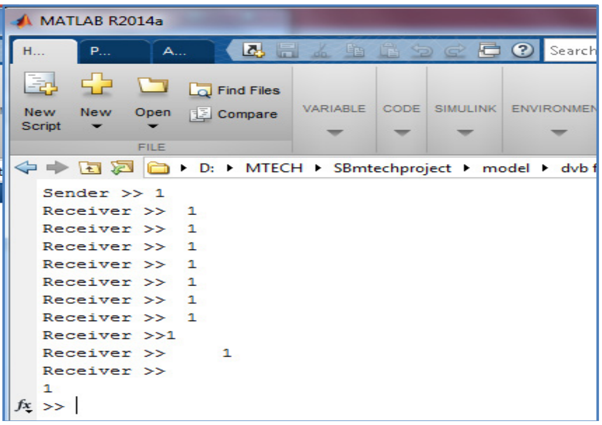


Fig. 9(b): Text Data reception with DTMF-DVB

After the successful transmission of tone, text data are used as the user data. In this case the performance of the system is analysed on the basis of probability of repetition; done on the basis of retransmitting the same data over and over again and noting the performance of the system. Unlike the previous cases, the error percentage is very high in case of text transmission as is seen in Fig 9(a). Therefore, to tackle this problem additional another widely proven Dual Tone Multi Frequency (DTMF) [13-14] technology is used prior to DVB encoding.

System Consideration:

- Code rate: ½
- Modulation: QPSK
- User data: Alphabet/Numeric

The reliability of the system is widely improved with the application of DTMF and as Fig. 9(b) says that percentage of error in the transmission is negligible (observation taken the repeatedly transmitting and receiving same information).

4. Conclusion

DVB is widely proven technology which is undergoing further development in the form of high data-rate support for high definition television. It is providing near real life experience and is being accepted very positively worldwide,especially regions where cable TV service is impossible like in hilly regions. The use of channel encoding plays a greatly, even under low SNR condition. Also the use of higher modulation technique leads the system capacity closer to the Shannon's limit. BER achieved nearly 1E-04 at high SNR. After BER performance verification, multimedia transmission capability is performed which shows very promising result for all the cases i.e. text, audio, and image. The system is then used for actual open range testing and verification in terms of multimedia communication like audio, text, image under different channel conditions.

The DVB system, thus developed is tested for different channel condition, including multipath shows a promising result. It is observed that the system provides reliable communication for all the cases, though it has various constraints like data rate achieved is minimal; video data transfer still to be explored; which need to be solved for real time communication.

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