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Enactment of LDPC Code Over DVB-S2 Link System for BER Analysis Using MATLAB

Shariq Siraj Uddin Ghouri, Sajid Saleem and Syed Sajjad Haider Zaidi

Abstract In this paper, Digital Video Broadcast—Satellite Second Generation (DVB-S2) Simulink model on MATLAB is evaluated. To analyze the performance especially while working on 8PSK modulation, FEC rates as 3/4, 3/5, and 9/10 along with low-density parity-check (LDPC) codes chained with Bose–Chaudhuri–Hochquenghem (BCH) codes for effective transmission. To examine this application performance, several entries of energy per symbol noise ratio (Es/No) were changed for model behavior detection. LDPC decoder iteration relationship analysis and LDPC bit error rate analysis have been carried out. After examining this has been evaluated at which FEC rate this model response finest.

Keywords 8PSK · LDPC · BCH · DVB-S2 · MATLAB · BER

1 Introduction

In 2003, Digital Video Broadcasting (DVB) project extended the second-generation design for applications related to satellite broadband services as DVB-S2 standard [ETSI EN 302 307-1] [1]. This classification allows satellite operations such as Internet access, digital satellite news gathering (DSNG), and TV and Radio broadcasting. DVB-S2 has been stated to fulfill three characteristics reasonable receiver complexity, total flexibility, and best transmission performance reaching the Shannon limit. Low-density parity-check (LDPC) codes as channel coding techniques

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and BPSK, QPSK, 8PSK, 16APSK, and 32APSK as latest ModCods have been adopted in combination for better working and performance of the system on nonlinear satellite channel. Maximum flexibility and synchronization specified by framing structure are considered for the worst low SNR configuration cases. Adaptive Coding Modulation (ACM) allows effective communication parameters in one-to-one links communication. Modes with the backward-compatibility allow integrated receivers and decoders of DVB-S2 which works during the period in transition [2].

The objective of this paper is to execute the DVB-S2 Link Simulink Model in MATLAB and study the performance especially while working on 8PSK modulation, FEC rates as 3/4, 3/5, and 9/10 along with low-density parity-check (LDPC) codes chained with Bose–Chaudhuri–Hochquenghem (BCH) codes for effective transmission. To analyze bit error rate and occurrence related to iteration which substantiates an adequate system performance with reduced system complexity and poor channel conditions. After analysis, this has been evaluated at which FEC rate this model response best and finally validate the results whether they are according to the standards of ESTI which states that lower the modulation coding rate the better will be the communication performance.

In this paper, 8PSK modulation along with LDPC and BCH channel coding techniques is used structure of this paper follows: Sect. 2 covers basics related to this research such as Shannon–Hartley Theorem, 8PSK bit mapping constellation and LDPC codes with DVB-S2 standard. Section 3 describes physical layer packet and frame structure of DVB-S2 along with the technical description of MATLAB Simulation Model. Section 4 reveals the simulation process leading to the results. In Sect. 5, conclusions are depicted.

2 Basics of this Research

2.1 Shannon–Hartley Theorem

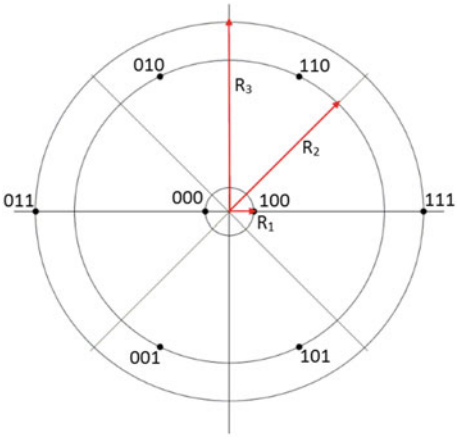
The Shannon–Hartley theorem depicts noisy channel capacity keeping random noise as assumption. Theorem states that

$$''C = B \log 2[1 + (\mathrm{S/N})]''$$

"(C = channel capacity in bps, B = channel bandwidth in Hz, S/N = signal-to-noise ratio at the channel output or receiver input)."

This theorem highlights signal-to-noise ratio importance and bandwidth in the application of communication. In order to provide channel capacity, increased bandwidth comprehends decreased signal power in provided channel capacity. "Increase in the channel bandwidth increases the channel capacity of a noisy channel", as would actually be suggested by the Shannon–Hartley theorem. "Increasing the bandwidth also increases noise resulting in decreasing the signal-to-noise" [3].

Fig. 1 8PSK constellation



2.2 Bit Mapping into 8PSK Constellation

Constellations of 8PSK and 8APSK are of eight points, distributed over three rings. The first ring consists of two points, second consist of four points, and on the third ring, two points are located (2 + 4+2 = 8) [1]. Constellation is illustrated in Fig. 1.

2.3 LDPC Coding Over DVB-S2 Link

The ETSI EN 302 307 standard has been developed to broadcast, provision of interactive services, to gather news and supports other services related to broadband satellite (DVB-S2) [4]. Coding schemes have increased the channel capacity. In 1960, Gallager while working over his seminal doctoral thesis invented LDPC code which can attain exceptionally low error rates close to channel capacity. Combination of low-density parity-check and Bose–Chaudhuri–Hochquenghem codes is the basic requirement of this scheme of code [5].

BCH codes outer layer is needed to rectify the sporadic type of errors generated through decoder of LDPC. DVB-S.2 offers quasi-error-free process regardless of any type of transmission medium (error rate of packet is below 10^{-7}) from 0.7 dB till 1 dB according to "Shannon limit" [6].

3 DVB-S2 Standard with Application

3.1 DVB-S2 Packet and Frame Structure

DVB-S2 standard comprises of two frames, one is the physical layer frame while other is an FEC frame. FEC frame includes the transmitted data in a structured form of the transport stream. Data for transmission contained within the frame of FEC known as generic data. Baseband header is a part of data field comprises of 80 bit in a data field layer [7]. Error protection code rate is then padded to baseband header and data field. Selected code rate to protect from error is expanded to the data block with the baseband header and afterward Bose–Chaudhuri–Hochquenghem code along with low-density parity-check code appended. FEC frame of DVB-S2 having frame length 16,200 or 64,800 bits is depicted in Fig. 2 [6].

3.2 Technical Description of Simulation Model

The DVB-S2 simulation is realized in Simulink, MATLAB is shown in Fig. 3.

Its main components are the following signal processing blocks:

- BBFRAME Buffering block—used to prepare BB (Base Band) frames to serve as input frames for the BCH encoder. All frames are arranged according to the BCH

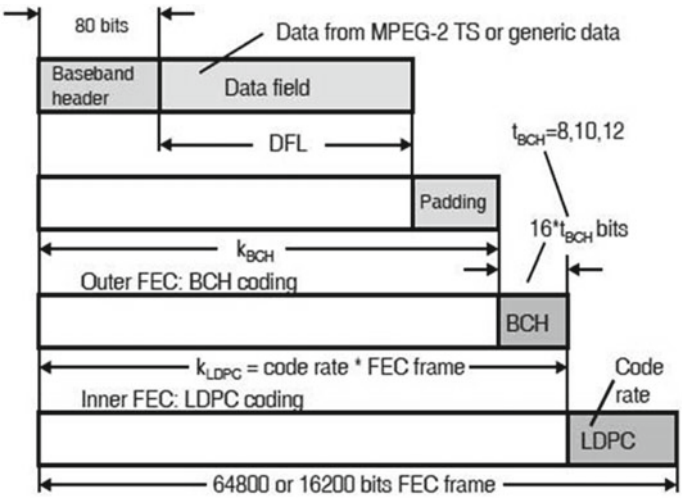


Fig. 2 FEC frame of DVB-S2

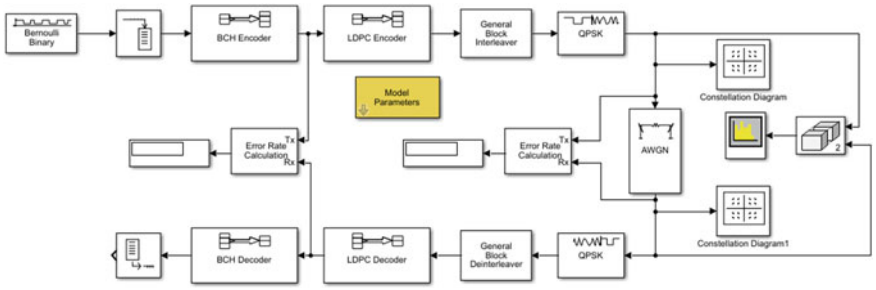


Fig. 3 Transceiver Simulink diagram of DVB-S2 system

encoder input data size. Input data frames (188 bytes or 1504 bit) are stacked up to the size determined by the number of information bits transferred within one BCH code word. Where necessary, the input BCH frame is stuffed with zeroes to ensure the fixed size of all encoder input frames.

- BCH encoder block—performs forward error correction encoding. BB frames prepared in the BBFRAME Buffering block are processed by the BCH encoder. BCH encoder adds redundant bits that are used for correction of errors caused by transmission over error-prone wireless channel.
- LDPC encoder block—performs internal error correction encoding based on parity bit calculation and their insertion into the information bit sequence. In this simulation, the output FEC frame (after BCH and LDPC encoding) will always retain a fixed size of 64,800 bits. LDPC encoding is the last block of the error correction processing.
- Block Interleaver—performs interleaving of bits from received FEC frames in order to distribute energy and reduce burst errors. In the simulation, bit interleaving is performed by writing the frame data into columns and reading three consecutive columns as rows.
- Modulator block—performs signal modulation. The simulation offers two modulation scheme options: QPSK with any of the eleven code ratio values, and 8PSK with the 3/5, 2/3, 3/4, 5/6, 8/9, or 9/10 code ratio.

The Simulink-designed simulation covers the basic mechanisms of signal processing and transmission during signal broadcast in the DVB-S2 system [8].

4 Results

This research has been carried out on Simulink MATLAB over which the designed transceiver DVB-S2 system has been re-evaluated. The transmitted signal (TX) was compared with the received signal (RX) after that qualitative and quantitative com-

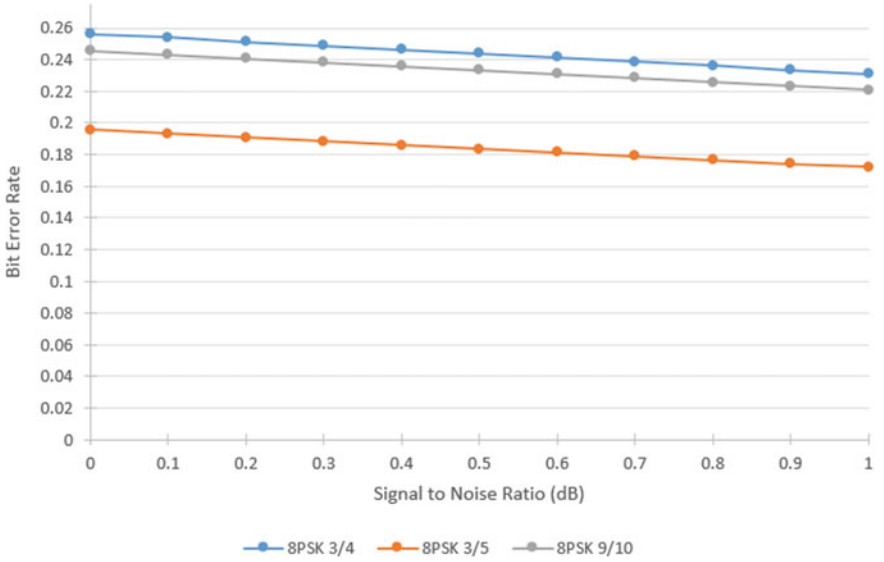


Fig. 4 LDPC BER result using DVB-S2 model—SNR ranges 0.1–1.0 dB

parison of the received signal was conducted in the form of occurrence of iteration and bit error rate analysis. Performance of this system and correction of the errors made by the LDPC codes was studied under the simulation. Modulated system was changed thrice (8PSK 3/4, 8PSK 3/5, 8PSK 9/10). Values of SNR ranging from 0.1 to 1 dB were changed and the system was put under test to analyze the results. LDPC codes were especially noted and evaluated at multiple values to test this model under the light of E_b/N_o's vector and LDPC curves were generated.

Figures 4 and 5 depict the SNR relationship at 8PSK 3/4, 8PSK 3/5 and 8PSK 9/10. These figures palpably noticed that 8PSK 3/5 converges over least BER values while 8PSK 3/4 and 8PSK 9/10 falls behind which is due to positive effects of the LDPC decoder.

Figure 6 shows no. of iterations distribution executed by decoder of LDPC coding.

Author has analyzed the performance of 8PSK modulation scheme along with the FEC rates which are 3/4, 3/5, and 9/10 over DVB-S2 Link Simulink Model in MATLAB. Detailed analysis has been done which results as 8PSK 3/5 performs best as its BER converges at 6 dB of signal-to-noise ratio and this model obeys ETSI standard for DVB-S2 Link.

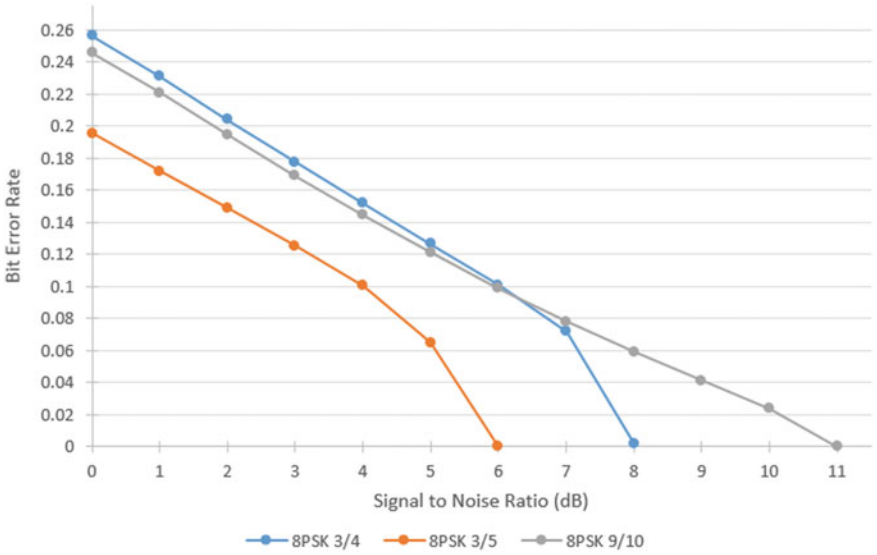


Fig. 5 LDPC BER result using DVB-S2 model—SNR ranges 0–11 dB

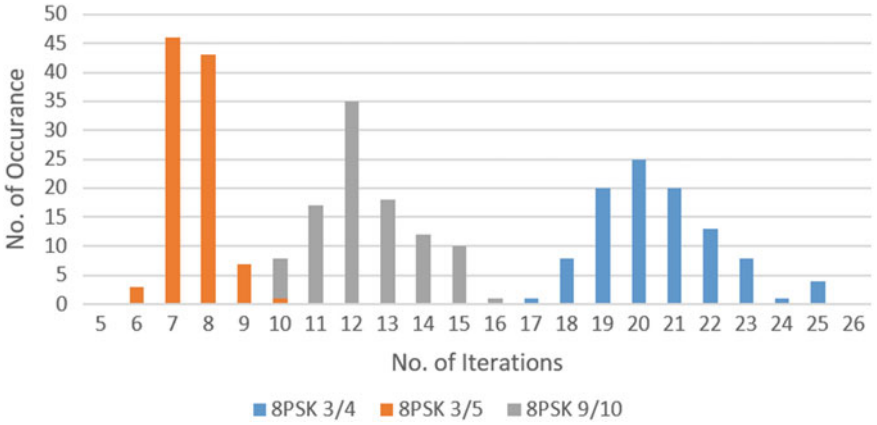


Fig. 6 No. of iterations distribution executed by the decoder of LDPC

5 Conclusions

Flourishing results has been simulated by the use of DVB-S2 Link Simulink Model in MATLAB where LDPC and BCH coders as well as decoders were incorporated. This model obeys the standard of ESTI according to performance regarding bit error rates. Overall demonstration of least ModCods produced improved bit error rates. Performance of the system is well appreciated as convergence of maximum limit in

the case of no. of iterations occurred remains within the count of 50. This simulation resolute the execution of LDPC codes at 8PSK 3/4, 8PSK 3/5, and 8PSK 9/10 and successfully attained the results as 8PSK 3/5 performs best as its BER converges at 6 dB of signal-to-noise ratio.

6 Future Work

Future work in this scope of research can be conducted by incorporating sound and video recorded stream as an input to DVB-S2 Link Simulink Model in MATLAB to analyze the stability of this system to understand and justify the scenarios working under ETSI standard [ETSI EN 302 307-2] [1].

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