# Modeling of a DVB-S.2 link with LDPC Coding

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***Abstract*-This technical paper presents the modeling and analysis of DVB-S.2 link with LDPC coding, particularly to determine the best modulation scheme for this type of communication link. This project used the MATLAB 7.5.0 (R2007b) software to model and simulates the DVB-S.2 link with LDPC coding. Through this software, the value of bit error rate (BER) was obtained by adjusting the value of Es/No which is in the range of -30 to 30 and the QPSK modulation scheme. This QPSK modulation scheme that was used in this software is 1/2, 1/3, 2/3, 2/5 and 3/5. From the simulation, 1/3 QPSK modulation was found to be the best modulation scheme because of its low BER.**

***Keywords: Low Density Parity Check (LDPC) coding, Bit error rate (BER), DVB-S2 Signal to Noise power ratio (Es/No)***

## I. Introduction

The state-of-the-art channel coding scheme used in the second generation Digital Video Broadcasting standard (DVB-S.2), planned to be deployed by DIRECTV in the United States is based on concatenation of LDPC (Low-Density Parity-Check) and BCH codes. LDPC codes, invented by Gallager in his seminal doctoral thesis in 1960, can achieve extremely low error rates near channel capacity by using a low-complexity iterative decoding algorithm. The outer BCH codes are used to correct sporadic errors made by the LDPC decoder.

The channel codes for DVB-S.2 provide a significant capacity gain over DVB-S under the same transmission conditions and allow Quasi-Error-Free operation (packet error rate below $10^{-7}$) at about 0.7 dB to 1 dB from the Shannon limit, depending on the transmission mode.

## II. Problem Statement

The Digital Video Broadcasting (DVB) Project was founded in 1993 by the European Telecommunications Standards Institute (ETSI) with the goal of standardizing digital television services [2]. Turbo code is used in DVB-S while LDPC code is used in DVB-S2 as their coding code. LDPC codes have a major advantage compared with turbo code in term of their power consumption. This is because LDPC coding is less computationally complex to decode at the receiver; hence the power consumption in the receiver will be less for LDPC codes than for turbo codes. LDPC codes achieve approximately the same, near-optimum performance that turbo codes achieve. When LDPC is coupled with BCH coding, this concatenated LDPC and BCH coding scheme provides performance very close to the theoretical Shannon limit resulting in 30% bandwidth efficiency increase over DVB-S systems [6].This bandwidth will allow DVB-S2 to transmit more content at the same cost. DVB-S2 signals require an average of 2.5 dB less link margin than DVB-S signal with the same error protection overhead. This means smaller antenna and cheaper satellites are used in DVB-S2. It also supports a much wider variety of input data formats, including multiple transport streams, generic data formats and more. In Malaysia, only a few researches in the DVB-S2 link including LDPC coding is done because DVB-S2 was just recently introduced in year 2004 [2]. This research provides insight into the DV-S2 link model and in terms of the best modulation schemes to use in this type of communication link.

### II.I Objective and Scope of Study

The purpose of this project is to find which value of the QPSK modulation schemes offer the lowest bit error rate (BER) with the DVB-S2 link model. The range of Es/No is selected from -30 to 30. This range of number is selected to observe the value of BER. In order to classify the best result of QPSK modulation, only the lower value of BER can be conclude as the best result.

This model models the BCH encoder, LDPC encoder, interleaver, modulator, as well as their counterparts in the receiver, according to the DVB-S.2 standard.

DVB-S was only specified with QPSK modulation, which allows a maximum of 2 bits/Sec/Hz efficiency in a satellite link. This is a limitation for professional applications, which can use larger satellite dishes and smaller symbol rates than the consumer transmissions and hence can support more advanced modulation schemes. There are 11 values of QPSK modulation scheme which is 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9 and 9/10. From these values only 1/2, 1/3, 2/3, 2/5, 3/5 is used to simulate the DVB-S.2 link with LDPC coding.

### II.II Low Density Parity Check

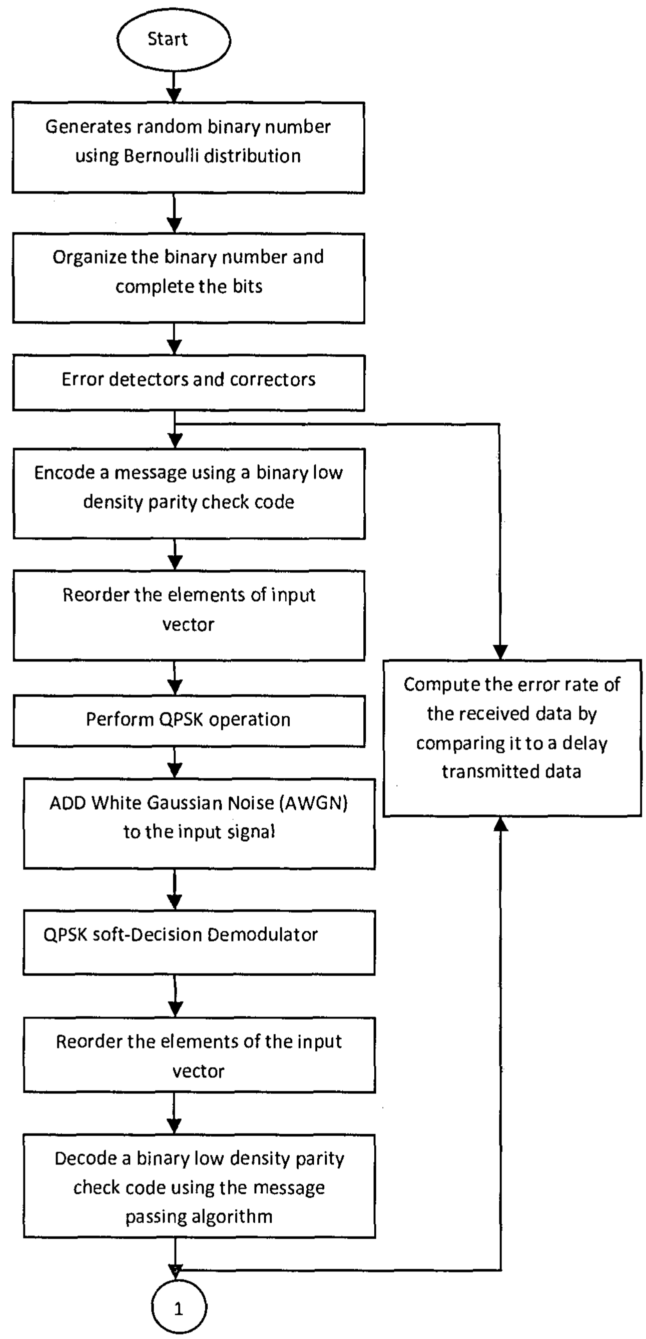
The new standard for digital video broadcast DVB-S2 features Low-Density Parity-Check (LDPC) codes as their channel coding scheme. The codes are defined for various code rates with a block size of 64800 which allows a transmission close to the theoretical limits [2]. When the data is transmitted from the transmitter to receiver, errors would be produced at the receiver. Therefore, to overcome this problem the long code is used to correct the errors. DVB-S2 delivers excellent performance, coming close to the Shannon limit, the theoretical maximum information transfer rate in a channel for a given noise level [1]. According to the Shannon theory, the bit rate will increase when the long code is used. This long codes approach the Shannon limit. The decoding of LDPC is an iterative process [2]. LDPC codes can achieve lower bit error rate. For DVB-S2, the LDPC code would reach 50 iterations. This amount of iterations would give the reading value more accuracy. However, this large amount of iterations can cause a delay before obtaining the results.

## III. Methodology

This project uses the MATLAB software to simulate the block diagram of DVB-S.2 link with LDPC coding.

### III.I Flow Chart of Modeling DVB-S.2 Link, including LDPC Coding

Figure 1 shows the flow chart of modeling DVB-S2 using LDPC coding. The Bernoulli Binary Generator block generates random binary numbers using a Bernoulli distribution. Then base-band frames (BBFRAME) will organize the binary number and complete the bits by appending the zero padding. Next BCH (Bose-Chaudhuri-Hoquenghem) encoder is used to perform BCH encoding. BCH codes used in communication system requiring Forward error correction (FEC) as an error detector and correctors where data transmitted through communication channel viable to errors and erasures. Concatenated BCH codes are introduced to avoid error floors at low bit error rates (BER).After that, LDPC code will encode a message by specified the parity-check matrix. Forward error correction associated with DVB-S2 is one of its most powerful features. This is based on the concatenation of BCH with LDPC codes. It provides a solution that is very near to the Shannon performance limit. Then, the general block interleaver will reorder the elements of the input bits. There are 11 of QPSK modulation scheme but in this project only 5 QPSK modulation scheme were studied because this 5 QPSK values would show the differences in the results. Next, White Gaussian Noise (AWGN) was added to the input signal. The input and output signals can be real or complex. The proposed soft-decision demodulator interface can operate at a symbol rate and replace the parallel to serial converter by locating the number of QPSK. Moreover, it can support high-order modulation modes. After that the deinterleaver will reorder the elements of the inputs bits. LDPC decoder will decode a binary low density parity check code using a message passing algorithm. BCH decoder will recover a binary message from a binary BCH codeword. BBFRAME will reorganize the binary number. Finally, after the process of BCH encoder and LDPC decoder is completed, the error rate of the received data will be calculated.



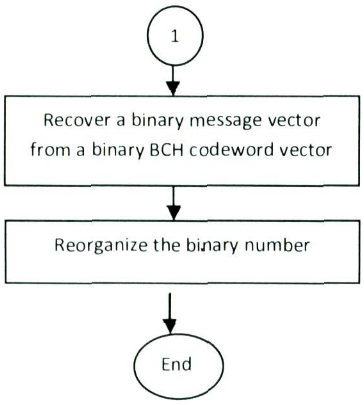



Figure 1: Modeling of DVB-S2 link, including LDPC coding

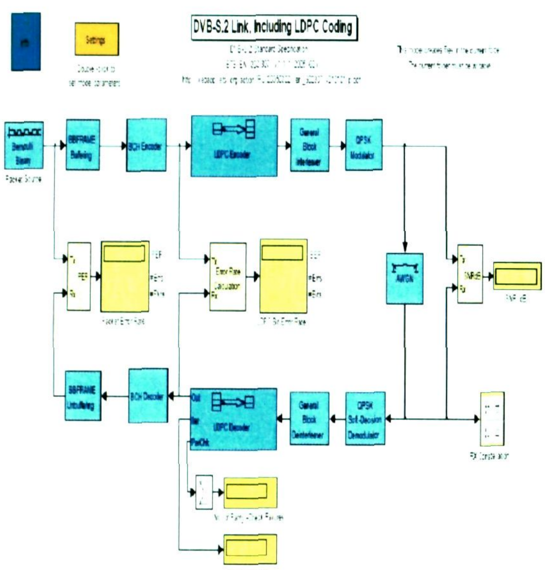



Figure 2: Blok Diagram of Modeling of DVB-S2 link, including LDPC

### III.II Flow Chart of DVB-S2 Link Simulation

Figure 3 shows the process of simulation of the DVB-S2 model. Firstly, the number of QPSK modulation scheme was selected whether it is 1/3 qpsk, 1/2qpsk, 2/3 qpsk, 2/5 qpsk or 3/5 qpsk. Then the ranges of Es/No were varied from -30 to 30. This range of number is selected to see any significant changes of BER.

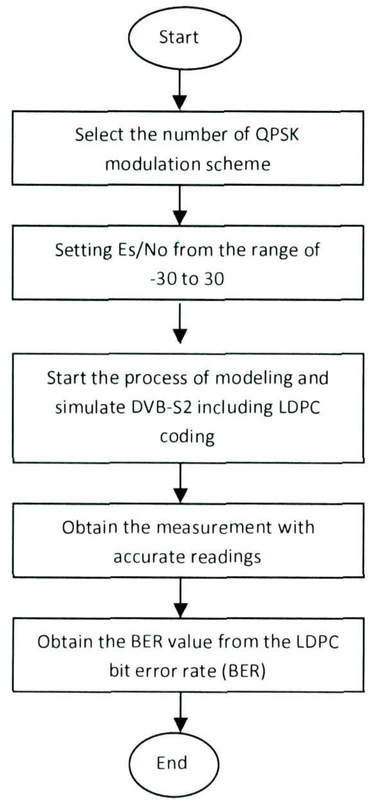



Figure 3: The simulation process of DVB-S2 including LDPC coding

## IV. Results and Discussion

Figure 4 shows the graph of ½ QPSK modulation scheme. When Es/No is equal to -30, the value of BER is 0.4878. This value is the highest compared with other Es/No. This value of BER will decrease accordingly depending on the value of Es/No. When Es/No is equal to 0, the value of BER is equal to 0.1298. This is the lowest value of BER before it turns to zeros. The value of BER is equal to 0 when Es/No equal to 1 until 30.

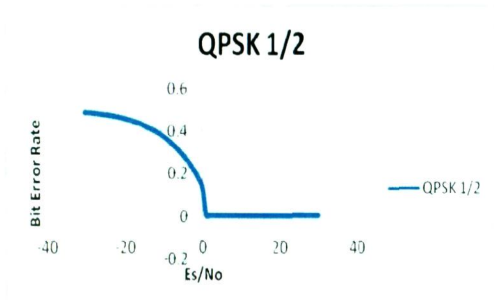



Figure 4: QPSK 1/2

Figure 5 shows the graph of 1/3QPSK modulation scheme. When Es/No is equal to -30, the value of BER is 0.4865. This value is the highest compared with other Es/No. This value of BER will decrease accordingly depending on the value of Es/No. When Es/No is equal to -3, the value of BER is equal to 0.01436. This is the lowest value of BER before it turns to zeros. The value of BER is equal to 0 when Es/No equal to -2 until 30.

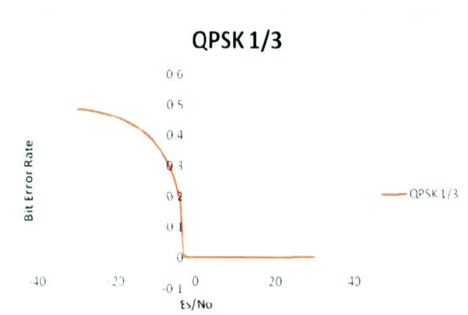



Figure 5: PQSK 1/3

Figure 6 shows the graph of 2/3 QPSK modulation scheme. When Es/No is equal to -30, the value of BER is 0.4856. This value is the highest compared with other Es/No. This value of BER will decrease accordingly depending on the value of Es/No. When Es/No is equal to 2, the value of BER is equal to 0.08087. This is the lowest value of BER before it turns to zeros. The value of BER is equal to 0 when Es/No equal to 3 until 30.

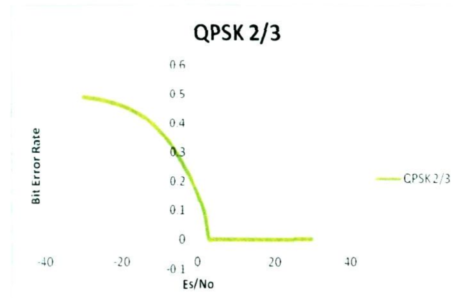



Figure 6: QPSK 2/3

Figure 7 shows the graph of 2/5 QPSK modulation scheme. When Es/No is equal to -30, the value of BER is 0.4874. This value is the highest compared with other Es/No. This value of BER will decrease accordingly depending on the value of Es/No. When Es/No is equal to -1, the value of BER is equal to 0.1331. This is the lowest value of BER before it turns to zeros. The value of BER is equal to 0 when Es/No equal to 0 until 30.

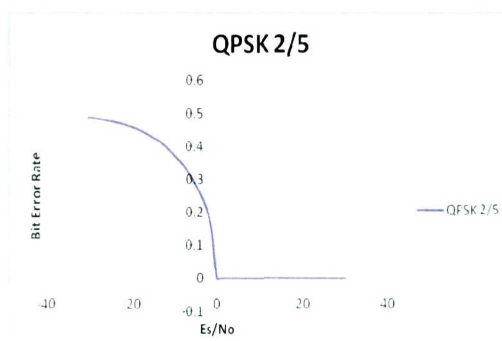
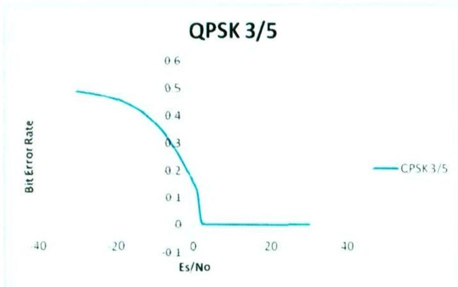



Figure 7: QPSK 2/5

Figure 8 shows the graph of 3/5 QPSK modulation scheme. When Es/No is equal to -30, the value of BER is 0.4878. This value is the highest compared with other Es/No. This value of BER will decrease accordingly depending on the value of Es/No. When Es/No is equal to 2, the value of BER is equal to 0.01235. This is the lowest value of BER before it




turns to zeros. The value of BER is equal to 0 from Es/No equal to 3 until 30.

Figure 9 below shows the comparison between QPSK modulation schemes. According to the theory the lowest value of BER indicates the best result. The graph shows that the lowest value of BER is produced when the 1/3 QPSK modulation scheme was used.

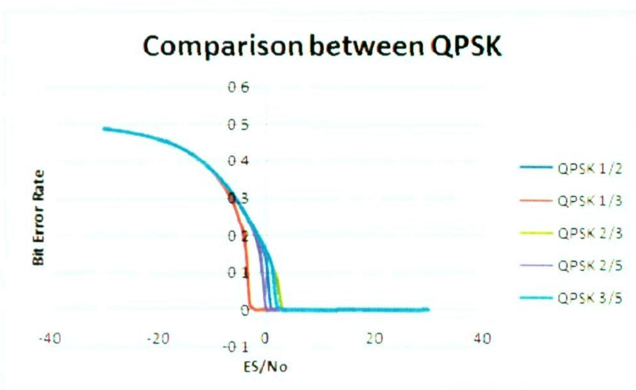



Figure 9: Comparison of QPSK

For 1/3 QPSK, when the Es/No is equal to -2, the BER is equal to 0. Starting from this value the BER value is zero. Then followed by 2/5 QPSK modulation scheme. When Es/No is equal to 0, BER starts to be zero.

Next followed by ½ QPSK, when Es/No is equal to 0, the value of BER becomes all zeros. Starting from Es/No equal to 3, the 2/3 QPSK and 3/5 QPSK give the same value of BER which is zero. The value of BER will decrease accordingly when the value of Es/No is increased. Similar theory occurs for other modulation schemes. The finding for this project showed that 1/3 QPSK is the best modulation scheme in modeling DVB-S2 including LDPC coding. This outcome is similar to a study done by TANDBERG television in United Kingdom [7] and West Virginia University [2]. Figure 9 shows the result that has been obtained by the West Virginia University. From this result shows that 1/3 QPSK modulation scheme is the best modulation scheme among 2/5, 1/2, 3/5 and 2/3 modulation scheme.

## V. Conclusion

Based on the results obtained in this project, 1/3 QPSK is the best modulation scheme for the DVB-S2 including LDPC coding model. This is because within the range of Es/No from -30 to 30, 1/3 QPSK modulation scheme was the first to achieve a zero BER. This was followed by 2/5 QPSK, 1/2 QPSK, 3/5 QPSK and 2/3 QPSK.

For future recommendation, this research could be further extended by using the 8QPSK modulation scheme in the DVB-S2 link including LDPC coding. This is because in broadcasting only QPSK and 8PSK are used as a modulation scheme. In addition, for future development, DVB-S2 can use Advance Code Modulation (ACM) to increase its capacity.

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