A performance comparision of LDPC, Hamming and BCH codes using MWD algorithm

Budharam Yogesh
218EC5123
Email: 218ec5123@nitrkl.ac.in
Department of Electronics and Communication Engineering
National Institute of Technology, Rourkela

Gannamani Raveendra
218EC5450
Email: 218ec5450@nitrkl.ac.in
Department of Electronics and communication Engineering
National Institute of Technology, Rourkela

***Abstract*—Design of a decoder in communication system is complex compared to an encoder. One such decoder of cyclic linear block codes with low complexity is Minimum Weight Decoder (MWD). This paper describes in detail the Minimum Weight Decoder. The decoder has been implemented for LDPC (16,8), BCH (15,7) and Hammimg (7,4) codes which are capable of detecting and correcting errors. The simulation results of each of the above mentioned codes are presented in this paper. The algorithm was implemented using MATLAB.**

Keywords—LDPC, Minimum Weight Decoder (MWD).

I. Introduction

Low-density parity-check (LDPC) codes are a class of error correction codes (ECC) which provide near-capacity performance. They were invented by Robert Gallager in 1962. However, these codes were neglected for more than 30 years, since the hardware at that time could not attain the requirements needed by the encoding process. With the increased capacity of computers and the development of relevant theories such as the belief propagation algorithm and Turbo codes, LDPC codes were rediscovered by Mackay and Neal in 1996. Low density parity check is dominant forward error correction coding technique used to encounter data errors caused through noisy channel during transmission. LDPC codes are widely used in many high speed communication system such as digital video broadcasting, Wi-MAX, 4G/5G wireless systems and many more.

The other such codes used in the paper are Hamming code, invented by Richard Hamming in 1950 and BCH code, invented by Bose, Chaudhuri and Hocquenghen in 1960. Hamming codes are defined as, it can detect two bit error and correct single bit error. The basic communication system is as shown in Fig. 1.

Minimum weight decoding algorithm is one of the message passing technique. The decoder we use in this paper is Minimum Weight decoder. All code-words in a cyclic block code are multiples of the generator polynomial G(x). Thus, to check if there is an error or not in the received word, the easiest test is to divide the received word by the generator polynomial. If the remainder of the division process is zero, then either the received word is a code-word, which has no error or it does not contains a detectable error pattern, If the remainder is not zero, then a detectable and possibly correctable error pattern has been found. This paper presents a detailed approach of using MWD to compare LDPC, BCH and Hamming codes over AWGN channel.

This paper is systematized as follows. Section I highlights an introduction part with basic concept of LDPC Codes and Minimum Weight Decoding (MWD) algorithm. Section II briefly gives an overview of work done using Minimum Weight Decoding (MWD) algorithm. Section III explains the process and mathematical analysis of minimum weight decoding algorithm, and the error correcting capability. Section IV gives a brief overview of MATLAB simulation and explanation regarding MATLAB simulation. Section V highlights on conclusion part in detail.

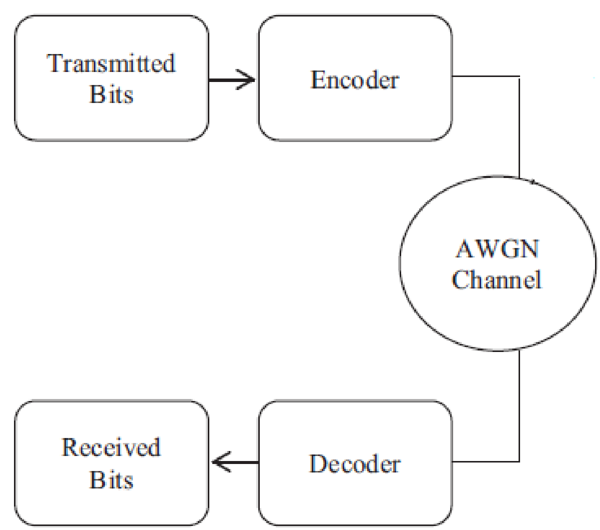

Fig. 1: Communication system

II. Literature Review

In this paper the design is implemented using MWD to compare LDPC, BCH and Hamming codes as in [1], which is an updated work of Hard-Decision Minimum Weight Decoder is described briefly [2]. The decoder for BCH (15,7) code is designed and implemented which is skillful for detecting double errors and also correcting it. In paper [3], the authors enlighten an upgrading to the MWD algorithm for Reed-Solomon (RS) codes.

III. MINIMUM WEIGHT DECODING ALGORITHM

Error detecting capability of a code is given by **d** - 1. Where d is the minimum distance between the codewords. Error Correcting capability is given by (**d** - 1)/2 for a code of (**n**,**k**,**d**), where **n** is the codeword length and **k** is the message length. Error Correcting capability of Hamming, BCH and LDPC codes are given in Fig.2

Error Correcting Codes (ECC)		
Code types	Codeword representation (n, k, d)	Error correcting capability $(t) = (d-1)/2$
Hamming code	$(7, 4, 3)$	1
BCH code	$(15, 7, 5)$	2
LDPC code	$(16, 8, 8)$	3

Fig. 2: Error correcting capability.

Minimum Weight Decoding Algorithm is one the decoding algorithm used for detecting and correcting the Hamming codes, BCH Codes and LDPC codes. It depends on the error correcting capability of the code. The main advantage of this algorithm is the low complexity. The flowchart in Fig.3, presents MWD algorithm.

The Minimum weight-decoding algorithm can be summarized in the following steps:

1) The received word R (x) is divided by the generator polynomial G (x) to calculate the syndrome.
2) The Hamming weight (W) of the syndrome is calculated.
3) The Hamming weight (W) is compared with the error correcting capability of the code (t). If
$$\mathbf{W} \leq \mathbf{t}$$
then the calculated syndrome is equal to the error pattern and the process continues at step (5).
4) A new syndrome is calculated, by first cyclically shifting the generator polynomial G(x) to the right the number of zeros in the left of the previous syndrome, and then dividing the previous syndrome by the generator polynomial before returning to step (2).
5) The calculated error pattern is added (modulo-2) addition to the received word to correct the introduced errors.

IV. MATLAB IMPLEMENTATION SPECIFICATIONS AND RESULTS

The Fig.4 gives the specifications used for **MATLAB** implementation. The simulation is done over an AWGN channel using BPSK modulation.

Performance of different codes are compared based on the Bit Error Rate (BER). All simulation were performed assuming code word transmitted over AWGN Channel via Binary phase shift keying. Fig. 5, 6, 7 represents the performance of BCH, Hamming and LDPC codes respectively, which shows the performance of LDPC code is better compared to other as in Fig. 8.

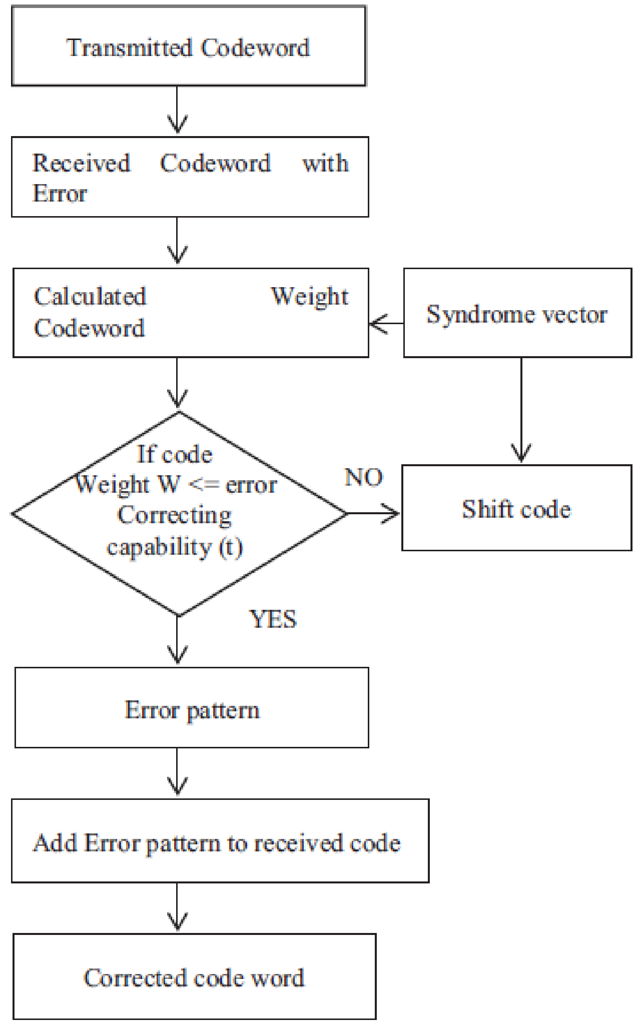

Fig. 3: Flowchart of the MWD algorithm.

Error Correcting Codes Matlab Simulation		
Hamming code	n_h K	7 4
BCH code	n_B k_B	15 7
LDPC code	N_L M_L	16 8
Channel Modulator		AWGN BPSK

Fig. 4: MATLAB Simulation Specifications.

V. CONCLUSION

The Minimum Weight decoding algorithm is presented in this paper, which is capable of detecting and correcting errors. The error performance of the LDPC code, BCH code and Hamming code are compared over an AWGN channel via BPSK modulation. The performance of LDPC code is better compared to the others as obtained from the simulations.

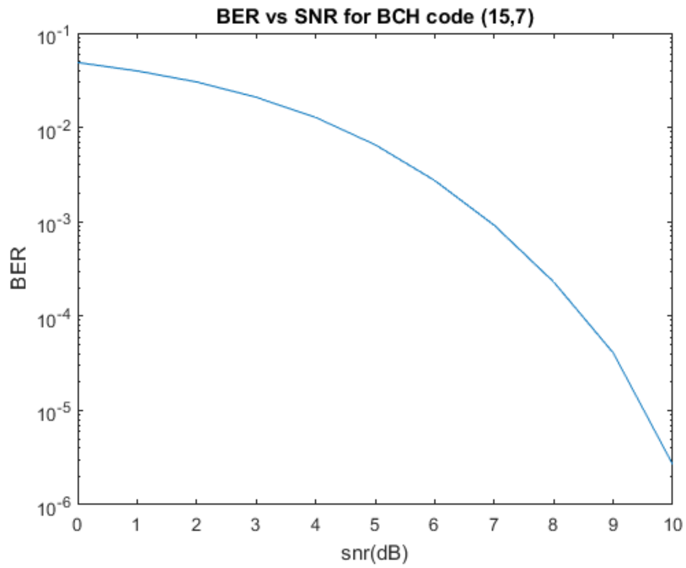

Fig. 5: The simulation result of block length (15,7) BCH Code.

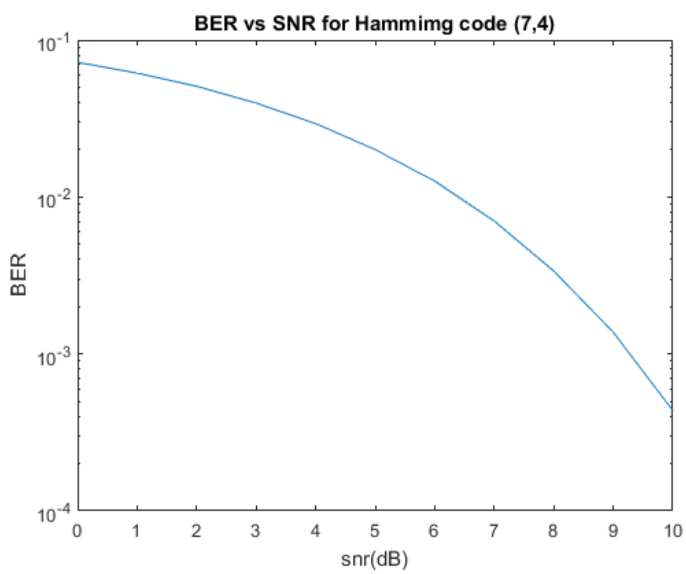

Fig. 6: The simulation result of block length (7,4) Hamming code.

REFERENCES

[1] S. Wahane, S. Kakde, A. Khobragade and W. Elmedany, "A systematic approach for achieving low bit error rate of LDPC decoder using MWD algorithm," 2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), Chennai, 2017, pp. 29-33.

[2] W. M. El-Medany, C. G. Harrison, P. G. Garrell and C. J. Hardy, "VHDL implmentation of a BCH minimum weight decoder for double error," Proceedings of the Eighteenth National Radio Science Conference. NRSC'2001 (IEEE Cat. No.01EX462), Mansoura, Egypt, 2001, pp. 361-368 vol.2.

[3] I. Martin, B. Honary and P. G. Farrell, "Modified minimum-weight decoding for Reed-Solomon codes," in Electronics Letters, vol. 31, no. 9, pp. 713-714, 27 April 1995.

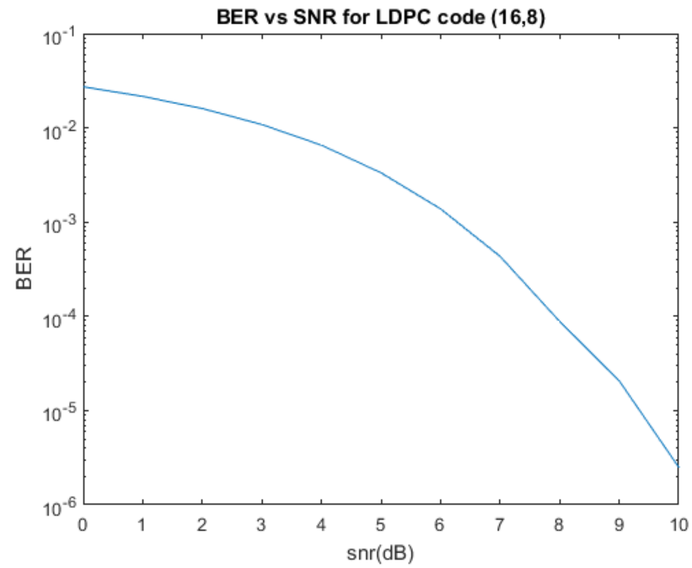

Fig. 7: The simulation result of block length (16,8) LDPC.

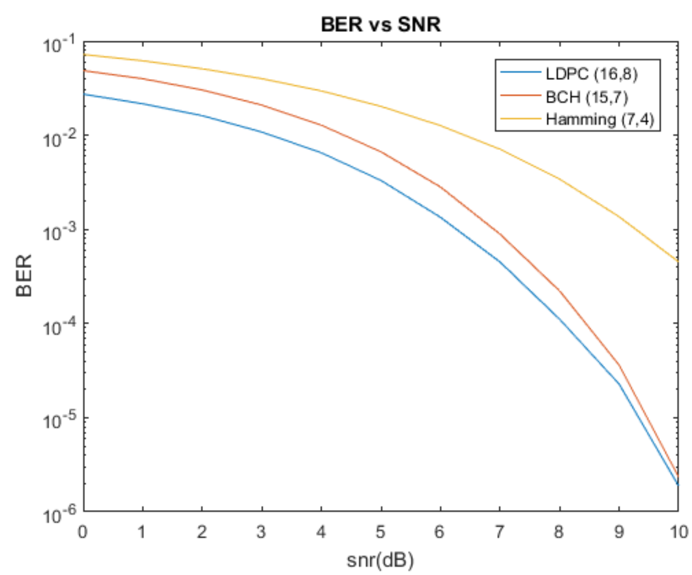

Fig. 8: The simulation result of block length (16,8) LDPC code comparison with (7,4) Hamming code and (15,7) BCH code.