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Performance Analysis of A Single Error Correcting (SEC) Code with Different Decoding Techniques

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ABSTRACT

The induced noise in communication channel is the main concern of designing any type of communication system. Transmitted signals are corrupted due to this channel noise which lead to bit errors at the receiver side. The Error Correcting Codes (ECCs) have been employed in the communication systems for minimizing these bit errors. The simplest form of Error Correcting Codes which is widely employed in this regard is known as Single Error Correcting (SEC) code. In this paper, the performance of a single error correcting code with hard and soft decision decoding schemes has been presented. A communication system with Binary Phase Shift Keying (BPSK) modulation technique and Additive White Gaussian Noise (AWGN) channel have been considered for this performance analysis. It has been observed that the Bit Error Rate (BER) performance of Soft Decision Decoding (SDD) is superior compared to the Hard Decision Decoding (HDD).
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Keywords– Single Error Correction (SEC) code. Hamming code, Binary Phase Shift Keying (BPSK), Bit Error Raate (BER), Hard Decission Decoding (HDD), Soft Decision Decoding (SDD).

I. INTRODUCTION

The major requirement of any communication system is the transmission of data with reliability. Bur the channel noise makes the communication systems unreliable. The transmitted signals are corrupted due to this channel noise. The main task of the receiver is to produce a received message that represents the original message as much as possible. The Error Correcting Codes (ECCs) have been employed in the communication systems for minimizing these bit errors. Single Error Correction (SEC) codes [1]-[2] are the simplest form of ECC which are capable of correcting single error and these codes have a minimum distance which is equal to three.

Various error correcting codes [1]-[7] have already been presented by several researcher for the improvement of the performance of communication systems. The performance of BCH code, cyclic code and hamming code in A WGN fading channel using BPSK and QPSK as the modulation scheme has been reported in [3]. This study is based on three type of error correction code without considering the time taken in each of the coded bits retransmission and other fading effects. This paper also investigates more parameters which affect the performance of the coding. Performances of Viterbi decoding algorithm and Turbo codes, i.e. Logarithmic-Maximum A Posteriori (Log-MAP) and Soft Output Viterbi algorithms (SOVA), have been analyzed in [4]. The performance evaluation and comparison of various concatenated error correcting codes using Binary Phase Shift Keying (BPSK) modulation scheme have been presented in [3]. In [5], the BER performance of OFDM-BPSK,-QPSK,- QAM over AWGN channel using forward Error correcting code has been presented. A detailed performance evaluation based on different modulation techniques, such as frequency shift keying (FSK), differential phase shift keying (DPSK), binary phase shift keying (BPSK), and offset quadrature phase-shift keying (OQPSK), using Hamming codes in a 500-kV line-of-sight substation smart grid environment with multichannel scheduling has been presented in [6].

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In this paper, the performance of a single error correcting code with hard and soft decision decoding schemes has been presented. A communication system with Binary Phase Shift Keying (BPSK) modulation technique and Additive White Gaussian Noise (AWGN) channel have been considered for this performance analysis. It has been observed that the Bit Error Rate (BER) performance of Soft Decision Decoding (SDD) is superior compared to the Hard Decision Decoding (HDD).

The rest of the paper is organized as follows. Section II provides the overview of SEC codes. The adopted methodology has been presented in section III. Results and discussions have been summarized in section IV and finally, section V concludes the paper.

II. OVERVIEW OF SEC CODE

A Single Error Correcting (SEC) code is cabable of correcting 1-bit random error in the received sequence. An (n, k) SEC code is entirely specified by its parity check matrix (H-matrix) which has (n-k) number of rows and n number of columns. Among these n columns, there are k number of data columns (denoted by d_i with i=1,2,…,k) and (n-k) number of parity columns (denoted by p_i with i-1, 2, …(n-k)). The (6, 3) Hamming code is the simplest form of SEC and The H-matrix of (6, 3) Hamming SEC code has been provided in Fig. 1 as an example.

p1	p2	p3	d1	d2	d3
1	0	0	0	1	1
0	1	0	1	0	1
0	0	1	1	1	1

Fig. 1: H-matrix of (6, 3) Hamming SEC

As shown in Fig. 1, the H-matrix (6, 3) Hamming code consists of three parity columns (p1, p2 and p3) and three data columns (d1, d2 and d3. The encoder for an Error Correcting Code (ECC) computes these parity bits and combine them with the data bits to form the codeword. The parity expressions for (6, 3) Hamming SEC code are expressed in equation (1).

$$p1 = d2 \oplus d3$$
$$p2 = d1 \oplus d3$$
$$p3 = d1 \oplus d2 \oplus d3$$

(1)

The codewords are modulated by using suitable modulation method and then transmitted through the communication channel where Additive White Gaussian Noise (AWGN) is added with the transmitted signals. This noisy version of the transmitted codewords are termed as received codeword (r).

The decoder of an ECC retrieves the original message from the received codeword. There are two types of decoding schemes to decode the received codeword. The first scheme of decoding is known as Hard Decission Decoding (HDD). In this scheme of decoding the distances of a received codeword is computed with all transmitted code words and the code word which provides the minimum distance is assumed as the transmitted codeword.

In the second scheme of decoding, Euclidian distances of a received codeword is computed with all transmitted code words and the code word which provides the maximum Euclidian distance is assumed as the transmitted codeword. This scheme of SDD is known as Maximum Likelihood Decoding (MLD)..

III. METHODOLOGY

In this work, we have analyzed the Bit Error Rate (BER) performance of (6,3) Hamming code in AGGN channel for communication systems. The block diagram of methodology adopted for BER simulation of Hamming (6,3) codehas been shownin Fig.2.

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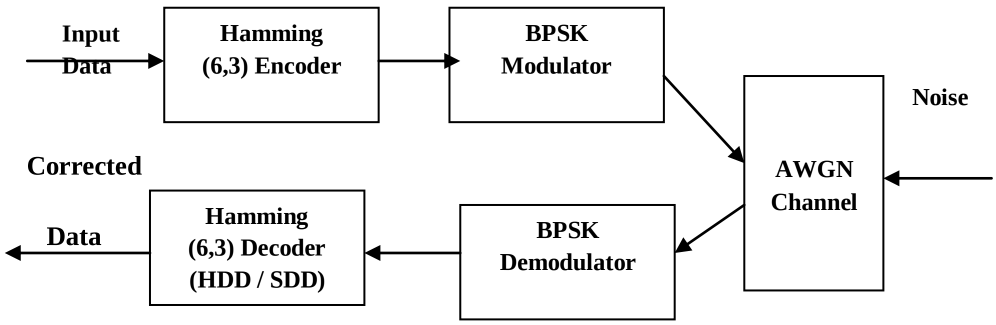

Fig. 2: Block diagram of (6, 3) Hamming code employed in communication system

As shown in Fig. 2, the input binary data is encoded by 6,3) Hamming encoder and then it provided as the input to BPSK modulator. The BPSK modulator maps the binart data 0 and 1 to +1V and -1V respectively. The noise is added in communication channel and bit errors occur. The first task of a receiver is to demodulate the incoming signal and provide demodulated signal to the (6,3) Hamming decoder. The errors are detected and corrected in (6,3) Hamming decoder block to provide the corrected data. We have computed the BER of Hamming (6,3) code using MATLAB software and we have made the following assumptions in the simulation process.

- Total number of bits transmitted (N): 10000-bit
- Code Rate(R) : 1/2
- Modulation: BPSK
- Decoding: HDD/SDD

The BER performances of Hamming code for different decoding techniques are presented in the following section.

III. RESULTS AND DISSCUSSIONS

The Bit Error Rate (BER) performance of Binary Phase Shift Keying (BPSK) over Additive White Gaussian Noise (AWGN) channel with out employing an Error Correction Code (ECC) has been shown in Fig. 3. The maximum and minimum values of BER are 0.0563 and 0 respectively. So the BER of BPSK modulation in AWGN channel is higher compared to the minimum value of BER which is required for an acceptable communication system and error correction codes are required to reduce the BER.

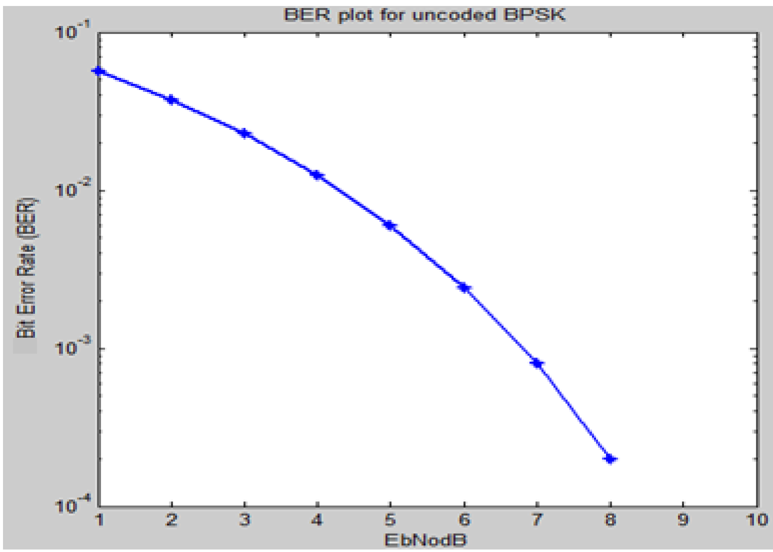

Fig. 3: EbNodB vs. BER plot for BPSK over AWGN

The Bit Error Rate (BER) performance of Binary Phase Shift Keying (BPSK) over Additive White Gaussian Noise (AWGN) channel with (6, 3) Hamming code and Hard Decision Decoding (HDD) as the decoding scheme has been shown in Fig. 4. The maximum and minimum values of BER are 0.0612 and 2 x 10-5

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respectively. So (6, 3) Hamming code with HDD is not at all suitable for reducing the BER of BPSK for communication systems.

The Bit Error Rate (BER) performance of Binary Phase Shift Keying (BPSK) over Additive White Gaussian Noise (AWGN) channel with (6, 3) Hamming code and SoftDecision Decoding (SDD) as the decoding scheme has been shown in Fig. 4. The maximum and minimum values of BER are 0.0522 and 0 respectively. So (6, 3) Hamming code with SDD is the most suitable for reducing the BER of BPSK for communication systems compared to HDD coded and uncoded BPSK.

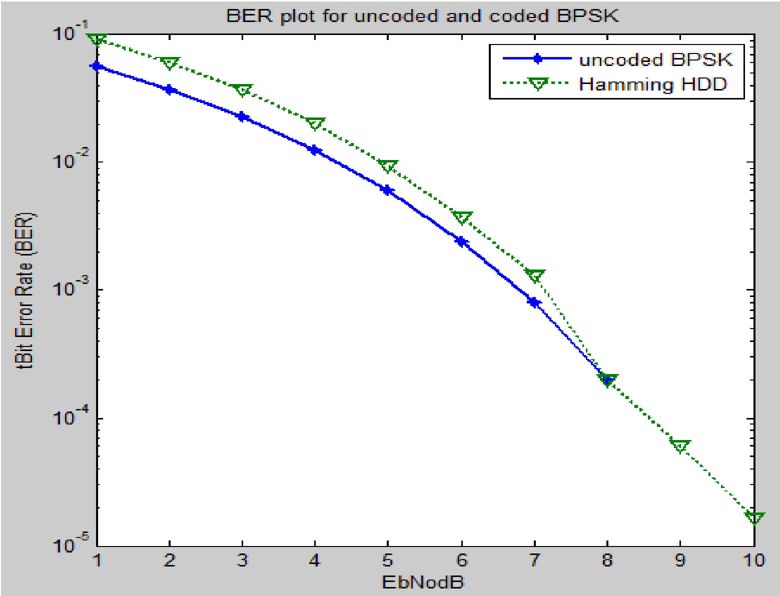

Fig. 4: EbNodB vs. BER plot for BPSK over AWGN with (6, 3) Hamming code and HDD scheme

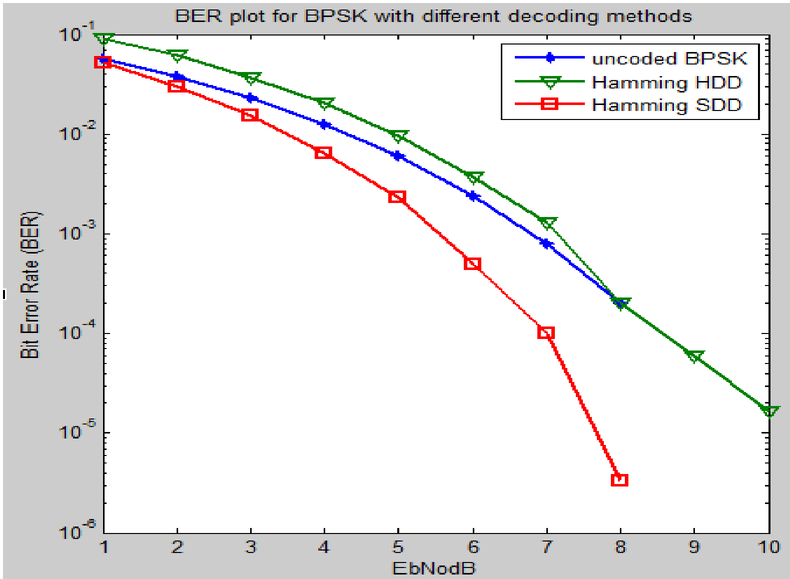

Fig. 5: EbNodB vs. BER plot for BPSK over AWGN with (6, 3) Hamming code and HDD scheme

V. CONCLUSSION

In this paper, the performance of a single error correcting code with hard and soft decision decoding schemes has been presented. A communication system with Binary Phase Shift Keying (BPSK) modulation technique and Additive White Gaussian Noise (AWGN) channel have been considered for this performance analysis. It has been observed that the Bit Error Rate (BER) performance of Soft Decision Decoding (SDD) is superior compared to the Hard Decision Decoding (HDD).

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