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Analysis of BCH Codes for Different Channel Conditions in Lab VIEW

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***Abstract*- In recent past digital data and its transmission over either in wired or wireless channel with the minimum bandwidth requirement and high data rate is playing vital role in communication field. According to studies done by Broadband Commission for mobile communication data transmission over wireless channel decides the growth in economic and social sector of the country. Increase in electronic gadgets and number of users in a geographical area is demanding the efficient utilization of bandwidth by assuring more number of users in a limited channel and high speed data rates in communication devices. In this paper a brief study is done to analyze and estimate the channel parameters for different channels considering BCH block code which is one of the efficient Forward Error Correction code.**

***Keywords*— Parity check bits, Galois field, coded modulation and fading channel**

I. INTRODUCTION

There is no chance of having 100% error free data transmission over channel which is obviously noisy when messages are encoded with zero redundant bits. There will be always possibility of error in a noisy channel due to multipath interference and signal fading due various internal and external impairment parameters. One way to enable the transmitted signals to withstand the effects of various channel impairments such as noise, fading and interference is coding message bits in such a way that if any bit that is being transmitted is received at the receiver incorrectly then the receiver is allowed to use the parity bits that are appended at the transmitter end and performs different decoding mechanisms to correct the incorrect bits. The method of encoding and decoding of a sequence of message bits is known as error control coding.

The conventional method used for error detection and correction is Automatic Repeat Request which sends an acknowledgement on receiving sent bit stream correctly and if not then the transmitter is sent with negative acknowledgement and the bit stream is resent over the channel. This is a tedious process and causes inefficient usage of bandwidth by sending the same data over the channel repeatedly. It is customary to encounter issues like low speed and memory management at both transmitter and receiver side in ARQ. The power level required to transmit the bit stream or the packets and device requirements will increase the production cost of the devices. Due to all of these reasons there emerged an intense need of a mechanism which performs the automatic detection of a bit when a train of bits is transmitted and corrects it on its own without any re-acknowledgement or negative acknowledgement. Since resending of the transmitted bit stream is not needed in this technique hence the name Forward Error Correction.

When a high speed binary datais transmitted over acommunication link error will occur depending on the media. The media can be twisted pair cable, coaxial cable, fiber optic cable, magnetic tape or radio or air link. These errors are caused by the various channel impairments like interference, distortions, noise, equipment malfunctions. The number of bits that are undergoing to the changes caused by these parameters for a given number of bits that is being transmitted is called bit error rate. The processof error detection and correction involves adding number of extrabits called redundant bits which facilitates the detection and correction of bits at the receiver end. The goal of coding techniques is to get transmission channelsto operate at their maximumdata transmission capacity.

In Galois field a new symbol called α is introduced along with the elements 0 and 1 in GF (2). Galois field of 2^m-1 elements is constructed from binary field GF (2) represented as GF (2^m) called extension field and elements form all the roots of $x^{2^\wedge m-1}$. An irreducible polynomial whose degree is n which is lowest possible

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value over GF (2) and dividing $x^{2^{\wedge}m-1}$ them it is called primitive polynomial. The root of the primitive polynomial is called primitive element. If f (x) is a polynomial in GF (2) and β is a root in Gf (2^m) then f ($\beta^{2^{\wedge}l}$) = 0 for l > 0. If f (x) is the smallest degree polynomial for which β is a root then f (x) is called minimal. If there exist a smallest nonzero element e such that $\beta^{2^{\wedge}e} = \beta$ and which is also a degree of polynomial over GF (2), then

$$F(x) = \prod_{i=0}^{e-1}(x + \beta^{2^i}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The message to be transmitted isprocessed in such a way that additional bits are created and added to the original message. These extra bits help in the detection and correction of the message bits received at the receiver. The key point about channel coding is it takes more time to transmit due to the presence of extra bits. As they consume more time for transmission they are known as overhead. Channel encoding involves error detection and error correction codes.

II. RELATED WORK

Recent research in digital communication has taken the advantage of MIMO technologies to achieve reliable communication with 10-100 times increase of data rate in comparison to traditional systems. The powerful turbo equalization and FEC coding techniques enable both single carrier modulation and OFDM systems to combat triply selective channels [1]. Low complexity techniques are possible with both turbo linear equalizers and turbo soft decision feedback equalizers in both the time and frequency domains.

Compared with non-coded BPSK system, all link schemes can obtain a large coding gain. Started with RS (127, 63) and BCH (15, 7, 2) all coding techniques obtain the encoding 33.4 dB above [2]. Code high-rate coding, low signal to noise ratio when operating in low rate coding codes with better performance when there is noise signal above a certain value. The total rate of coding and optimal performance by concatenating several different techniques involved in the simulation and analysis. Parameters like low complexity, time and frequency domain techniques in both turbo and convolution codes, linear equalization in soft decision feedback are possible in BCH coding technique.

The parameters must be selected in the design of interleaved code includes a BCH code parameters (n, k, t) and the number of interleaving I. (interleaving with I successive bits in each code word are separated in the flow channel bits by adding bits from I-1 other code word) typical [3]. Specification of the desired performance is that it provides a method of encoding a predetermined error improvement rate channels shows that maximum of un-coded error rate in bits can be implemented.

In recent years there has been increased demand in the video transmission over a direct broadcast satellite channel. But forward error correction techniques cannot be widely used because determination of appropriate FEC levels required is computationally intensive problem, as it depends on many parameters like type of video to be transmitted, channel SNR and available bandwidth. Hence an optimally possible way of allocating transmission bandwidth for both source and channel coding is combined source-channel coding approach [4]. In addition to forward error correction in providing necessary quality of service, a new trend toward operating in a multi resolution frame work with digital multi-media transmission to provide different levels of service at different level of reception conditionsisimplemented.

In multiresolution frame encoding system each coded video stream is classified into a number of priority classes. The high priority class contains the most important information and intermediate and lowpriority classes contain nformation that contributes less for the quality of the video. Combining source and channel coding provides differential sensitivities of the video encoder output components while compensating for the different channel characteristics associated with the different priority classes.

Many digital communication systems employ both error control codes and run length constrained sequence codes. Dc free codes are most widely used in digital data storage systems and to add pilot signal in wireless systems [5]. When code rate, spectrum power and bandwidth efficiency are considered multimode dc free codes are found to be more efficient than the dc free codes. In addition to that most practical systems use error control codes like linear block codes, convolutional codes and BCH and RS codes to overcome channel impairments.

III. CHANNEL CODING AND CODED MODULATION

Expansion in channel bandwidth for signal transmission is the main drawback in combining coding with binary modulation techniques for achieving high coding gain. Comparatively more bandwidth is needed for un-coded information sequence and coded information sequence. By adding redundant bits to the transmitted sequence effect of channel noise can be minimized. Coding of information sequences provides an effective trade-off between channel bandwidth and transmitter power and is

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suitable for communication system that are designed to operate in power limited channels.BCH codes is a class of error-correcting block codes in which the coding and decoding procedures are characterized by low complexity, thus making these codes very suitable for a real implementation inlow-powerdevices [6]. Common power limited application fields are deep space, satellite and other wideband communication systems. Bandwidth is a tight concern for many applications like voice transmission, terrestrial microwave and some satellite channels. This is why coding by adding redundant bits is rarely used in band limited channels. This problem can be overcome by using coding techniques in conjunction with multilevel modulation techniques.

The basic idea of coded modulation is expanded modulation signal sets above which information symbols are encoded. The redundancy needed for the error control is provided by the same signal set without increasing the signaling rate and bandwidth. In power limited channels coding by adding additional redundant bits and concatenation of codes are also more suitable for error control [7].

a. Problem Definition

BCH code is analyzed by comparing it with different channel parameters signal to noise ratio and probability of error. Voice signal to be transmitted with a carrier of radio frequency range of 3 M Hertz to 300 G Hertz in free space and varying different channel models. By varying the different data word length, error correcting capability and digital modulation techniques considering noise present in the channel the probability of error is calculated and verified theoretically. The project aims at deciding the length of the code for which best possible result is obtained for a voice transmission with and without encoding.

b. Advantages of FEC

The use of error control coding technique brings back the same quality at the same power level. The code facilitates same error probability with lower power. All these trade-offs can be achieved by compromising in bandwidth. In each of the above mentioned trade-offs redundant bits and faster signaling is assumed hence the cost is expanded bandwidth. There exists an error correcting technique called trellis coded modulation which does notrequirefaster signaling or expanded bandwidth for a real time communication system. Apart from all these trade-offs FEC is capable of improving the system performance from 3dB to 5 dB especially in fading channels [8].

c. Methodology

The simulation and analysis of BCH coding with respect to channel parameters like BER, Probability of error is done in Lab VIEW software for easy understanding and explanation. The respective block diagram is as shown below in fig.1.

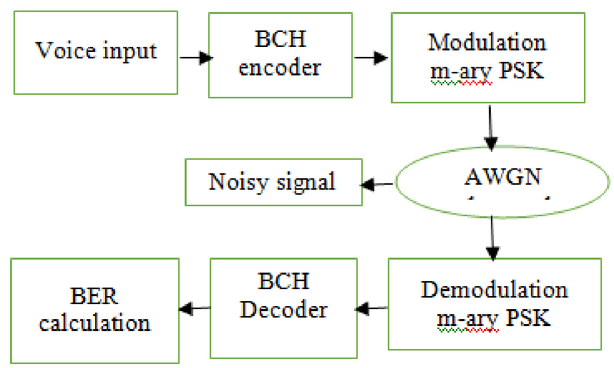

Fig.1 Block Diagram

An example which generalizes the direct memory less channel to channel with alphabets that are not discrete is the Gaussian channel with discrete input and output alphabet over the range $(-\infty,\infty)$. The channel adds noise to the symbols transmitted and noise is a Gaussian random variable. For this also conditional probability will be the product of individual independent element probabilities. The soft decision of the decoder will be decided by the whether the output consists of continuous alphabet or itsquantizedapproximation. It is not possible to characterize the detection process with channel symbolerrorprobabilityin hard decision channels. The decoder in soft decision channel makes decisions in such a way that it is very difficult to label as correct or incorrect. There cannot be a probabilityofmakingan error as there are no firm decisions. Soft decision decoders are implementable but hard decision decoders are easier in case of block codes and hence hard decision block decoders are most widely used in real time applications.

IV EXPERIMENTAL RESULTS

a. Results obtained in Lab VIEW

For results and discussion BCH (63, 51, 2) where n=63, k=51 and t=2 is taken as codec standard [9] output is validated for binary and QPSK modulation techniques considering both AWGN and Bernoulli noise models

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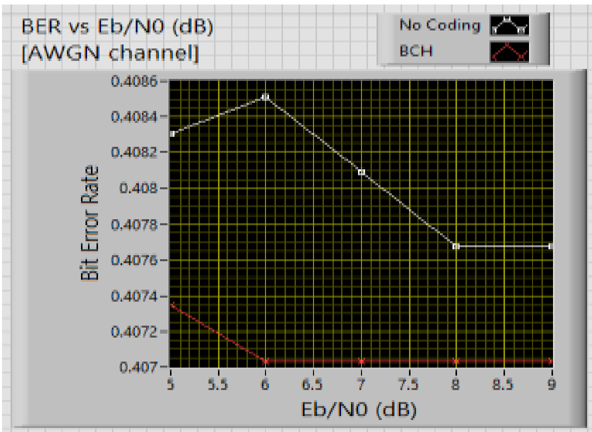

Fig.2 BER vs E_b/N_0variation in AWGN channel for binary PSK

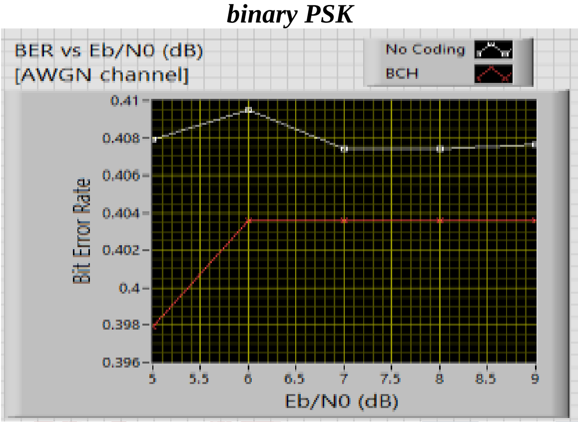

Fig.3 BER vs E_b/N_0variation in AWGN channel for QPSK

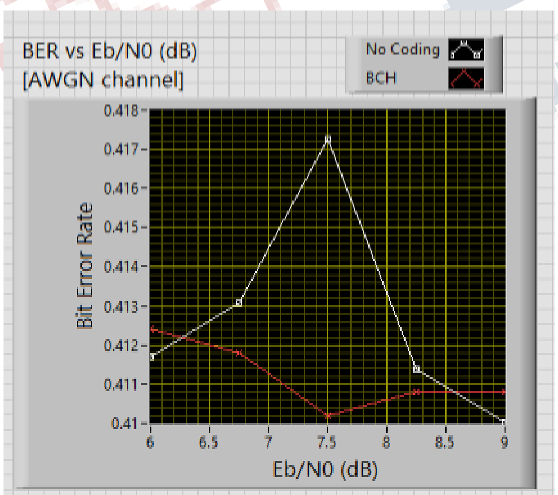

Fig.4 BERvsE_b/N_0variation in AWGN channel for 8-PSK

Different graphs are obtained for different PSK types considering number of symbols used for representing the modulated signal. Here only binary PSK, QPSK and 8-PSK are verified for BCH (63,51,2) coding. The respective plots are shown in Fig.2, Fig.3 and Fig.4.

Analysis

The results obtained in simulation can be tabulated as shown in table below.

AWGN	BER without coding	SNR in dB Without coding	BER With coding	SNR in dB With coding
PSK	407.6721m	173.44m	407.0298m	134.85m
QPSK	407.6219m	95.07m	403.5869m	36.30m
8-PSK	410.0423m	95.07m	410.7938m	172.43m

Table 1 tabulation of channel parameters for different PSK modulation

BER obtained without coding is more compared to that obtained with coding which implies that there is a significant improvement in BER by using BCH coding. Signal level required for transmission of data is also less in case of coding and is more in case when data is transmitted without coding. If modulation is extended for higher and higher levels then there will be no significant change in the BER and SNR required for modulation when BCH is used as an error control technique.

V CONCLUSION

BCH coding is effective only for lower levels of PSK modulation. If higher levels of modulation need to be applied then capacity approaching error control methods like LDPC codes, Turbo codes of can be applied [10].

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