

# Comparative Analysis of Different Channel Coding Techniques

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**Abstract**—Communication played important role in the development of human civilization. Today the heart of all techniques is the wireless communication. In wireless communication whenever data is transmitted or received error is produced due to dispersive effect, fading, attenuation, interference, noisy channel. For efficient data communication, it is necessary to receive errorless data. The goal of Channel coding techniques is to find code which transmit rapidly and can correct or detect many errors. Channel coding technique's code occupies more band width because redundant bits are added to it. The present research work compares BER analysis of different channel coding techniques. The numbers of bits transmitted is almost same for different channel coding techniques.

**Keywords**- Bournullin Binary, Channel Coding Techniques, AWGN, BER analysis.

## I. INTRODUCTION

In modern communication techniques the high data rate transmission is increased significantly, but high data rate transmission requires wide range bandwidth. Bandwidth is a burning issue for communication, so it's not wise decision to transmit data using more bandwidth. High data rate transmission in limited bandwidth leads to increased BER. The widespread use of efficient coding techniques over fading channels urges the researchers to determine suitable analytical methods for assessing their performance without resorting to cumbersome simulations [1]. Packet losses due to congestion, errors, or other transmission problems can introduce significant distortions. In this paper effectiveness of channel coding techniques in order to increase the quality of transmission across links with bursty losses and random error is considered. So in this paper different Channel coding techniques are used to reduce BER. For high data rate transmission different modulation and coding techniques are used. In wireless communication system, various transmission channels are used. There are two types of Channel coding techniques: (1) ARQ (Automatic Repeat Request), (2) FEC (Forward Error Correcting). Most of time in Digital Communication Forward Error Correcting technique is used, the advantage of using forward error correction is that retransmission of data can be avoided, the cost of higher

bandwidth requirements on average. In the various transmission channels, at the receiver end signals are received with different power and time delay due to the reflection, diffraction and scattering effects. The BER value of the wireless medium is high, so sometimes the information is lost due to high BER. So BER is key parameter for wireless communication, BER is used to evaluate the system which transmit data from one location to another location.

BER is most affected by SNR, if SNR increases BER decreases. There are two parameters which affects SNR:

$E_b$  = Error Function.

$N_o$  = Noise power spectral density.

During digital data transmission and storage operations, performance criterion is commonly determined by BER. The signal is disturbed by noise in transmission medium and causes data corruptions. Relation between signal and noise is described with SNR (signal-to-noise ratio). SNR is explained with signal power / noise power. BER is inversely proportional to SNR. If SNR is increased BER decreased.

## II. WIRELESS COMMUNICATION MODEL IMPLEMENTATION WITHOUT CHANNEL CODING

Communication model is implemented in Simulink shown in Figure-1. The Error rate calculation block compares the input data and data received after demodulation and calculates the error rate. The display will show the BER at the end of simulation [3].

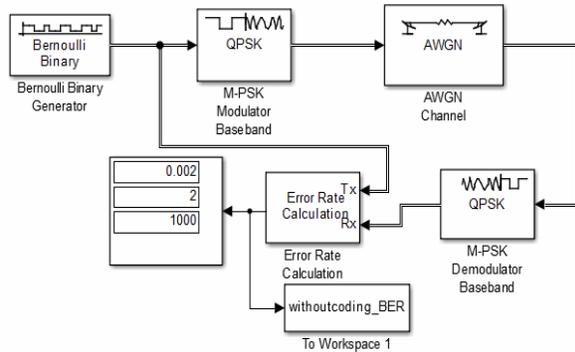


Fig.1

### A. AWGN channel

AWGN is commonly used to simulate background noise of the channel under study, in addition to multipath, terrain blocking, interference, ground clutter and self interference that modern radio systems encounter in terrestrial operation [4]. AWGN is Additive White Gaussian Noise Channel. AWGN channel has constant spectral density.

1) *Input Processing:* Column as channel parameter is set. Parameter gives the frame based output.

2) *Initial Seed:* If initial seed is increased in AWGN channel, BER will be decrease. It will generate random number which in turn is generated by Gaussian Noise Generator.

3) *Mode:* There are different mode like  $E_b/N_0$ , SNR,  $E_s/N_0$ , Variance from mask, Variance from port.  $E_b/N_0$  parameter is set, this parameter is ratio of bit energy to noise power spectral density.

Number of bits per symbol, Input signal power, Symbol period all these parameters are set to generate the noise variance in AWGN channel.

### B. Modulation Technique

There are different types of modulation like BPSK, QPSK, 16-PSK, 32-PSK, QAM etc. Each modulation technique has its own error function, so the performance of modulation technique is different at the time when noise is present. But high data rate transmission in limited bandwidth increase the BER. Some time it destroys the original data. The techniques which are generally used in wireless communication are QAM (Quadrature Amplitude Modulation) and QPSK (Quadrature phase shift keying). Higher order modulation technique transmits high data rate but higher order modulation techniques required high SNR. If the communication area is not larger than QAM technique is used, but in case of larger area the QPSK technique is more efficient than the QAM.

In QPSK two successive bits are combined reducing the bit rate or signaling rate and also bandwidth of the channel which is a main resource of communication system. Combination of two bits creates for distinct symbols [5]. QPSK requires less

bandwidth than BPSK to be transmitted for same length of data. BER of BPSK and QPSK is almost same. In all other technique BER is comparatively high. 64-PSK has highest Bit Error Rate from other lower order modulation Technique. QPSK technique is also known as 4-PSK.

1) *M-PSK Modulation:* Modulation technique is used at transmitter.

a) *M-ary:* QPSK technique is used so  $M=4$

b) *Phase Offset (rad):* QPSK technique is used according to that  $\pi/4$ .

2) *M-PSK Demodulation:* Demodulation technique is used at receiver.

### III. BCH CODING TECHNIQUE IMPLEMENTATION

Bose Chaudhari Hocquenhem code is known as BCH Coding. BCH is most efficient coding technique in Linear Block Coding techniques.

Block length,  $n=2^m-1$

Number of check bits,  $(n-k) \leq mt$

Minimum Hamming distance,  $d_{min} \geq (2t+1)$

For any integer 'm' and 't', there is a binary (n,k) BCH codes. BCH coding gives the flexibility for choice of parameters. BCH code can correct 't' number of error or less than 't' number of error. If BCH code is used to correct single error that will work as same as hamming code. BCH code is mostly used in wireless communication. In BCH coding when SNR is higher BER is almost zero. BCH code implemented in simulink model is shown in Figure-2. BER comparative analysis is shown in Graph-1.

#### A. BCH Encoder:

There are three options given to the BCH Encoder block:

1) *Specific Primitive Polynomial:* It convert nonnegative decimal integer 'd' to a binary row vector. If 'd' is vector output it is in form of matrix and each row of which is the binary form of the corresponding element in 'd'.

2) *Specific Generator Polynomial:* A generator polynomial using a Galois row vector that lists the polynomial's coefficients in order of descending powers of the variable. Generator polynomial is generated by bchgenpoly (15, 5).

3) *Puncture Code:* When encoder work on different code words per frame, same puncture pattern is applied to all code words. Puncture codeword is used to remove parity symbol

#### B. BCH Decoder:

1) *Enable erasures input port:* If receiver generates erasures, performance improves specifically in fading channel.

2) *Output number of error corrected:* It indicates number of error are corrected.

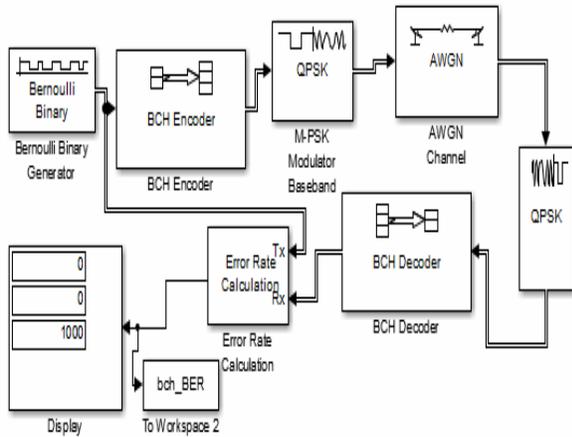
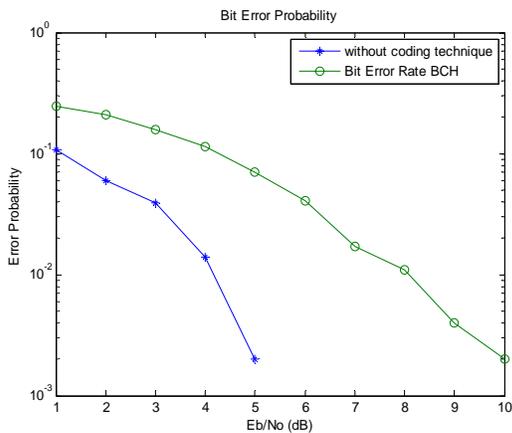


Fig-2



Graph-1

Error probability at Different SNR is Shown in Table-I.

#### IV. HAMMING CODING TECHNIQUE IMPLEMENTATION

Hamming code is a type of Linear Block Code. Hamming code is (n,k) block code, where

- n= Number of data bits
- k= Number of encoded bits
- Number of check bits m=n-k.

To calculate number of check bits the Equation used,  
 $2^m \geq (m+k+1)$

In hamming coding technique as number of data bits increases, more number of error control bits is required to generate encoded bits as per Hamming Code.

Hamming coding technique is implemented in communication model in simulink is shown in Figure-3. In Hamming coding M=10 is taken.1023 bits are transmitted through a frame. Bit Error Rate is decreased after implementing hamming coding technique. Comparison of BER is shown in Graph-2.Error probability at different SNR shown in Table-I.

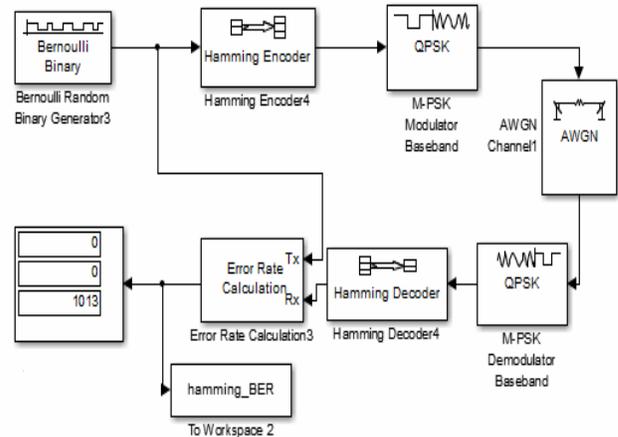
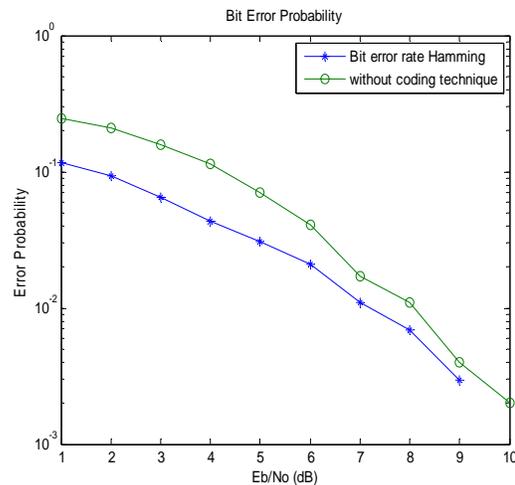


Fig-3



Graph-2

#### V. RS CODING TECHNIQUE IMPLEMENTATION

A Reed-Solomon code is one type of BCH coding technique. RS coding technique is used for non-binary data.

- Symbol length= k
- Block length, n= (2<sup>m</sup>-1) symbol.
- Message size= k
- Size of check code, (n-k)=2t
- Number of correctable symbol in error, t= (n-k)/2

RS codes in consortium with efficient coding techniques which are used in highly efficient use of redundancy, symbol size and block length which can be easily adjusted to put-up wide range of information data sizes. Implementation of RS coding technique in simulink is shown in Figure-5. Comparative analysis of RS coding is with without coding technique shown in Graph-3.

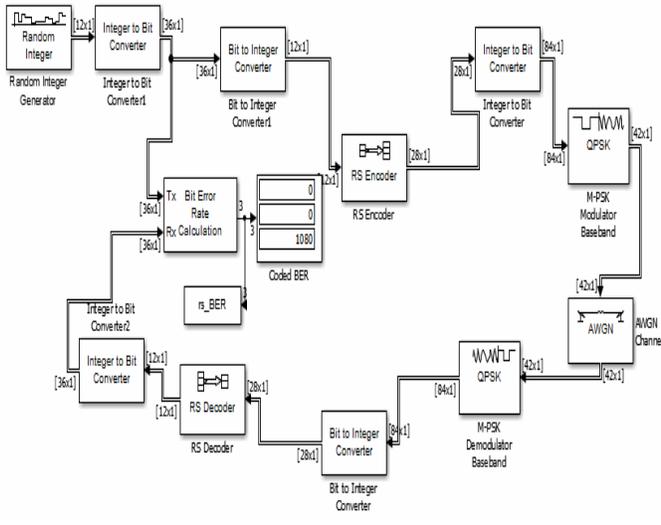


Fig-5

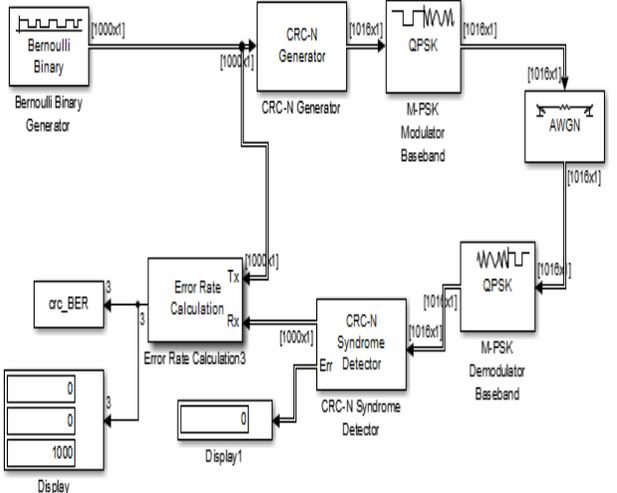
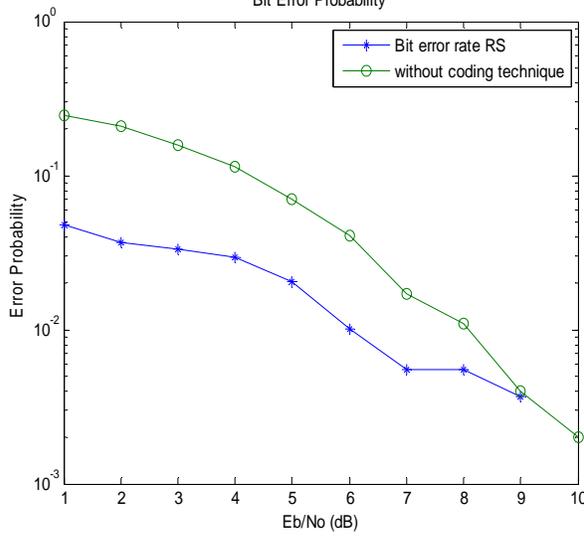
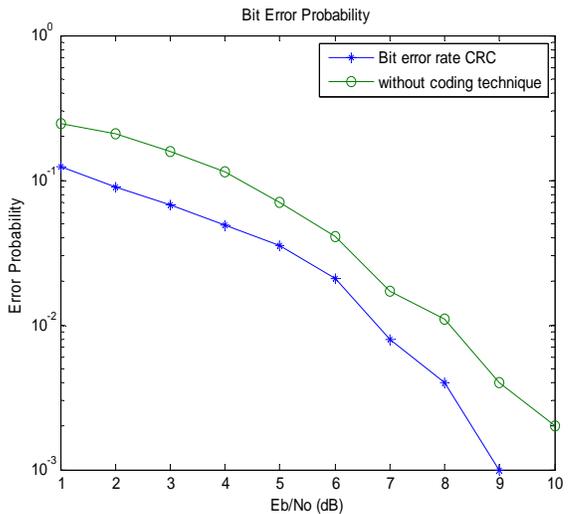


Fig-5



Graph-3



Graph-4

VI. CRC CODING TECHNIQUE IMPLEMENTATION

Cyclic Redundancy Check code is used in binary CRC .Binary (n, k) codes is able to detect the following error patterns,

- Length of error burst is n-k or less [6].
- Minimum Hamming distance is  $d_{min}- 1$  or fewer errors [6].

Error patterns with an odd number of errors, if the generator polynomial  $g(x)$  has an even number of nonzero coefficients. There are different types of CRC-16, CRC-32 etc. CRC coding technique implemented in simulink is shown in Figure-5.

Comparative analysis of CRC coding and without coding technique is shown in Graph-4.

VII. CONVOLUTION CODING TECHNIQUE IMPLEMENTATION

Convolution codes are usually described using two parameters: the code rate and the constraint length [3]. In convolution coding message length is fixed and coded symbol length is also fixed. It depends on current input symbol but also depend on previous input symbol that is shown in figure-6 [8]. Trellis structure of encoder shown in Figure-7 [8].

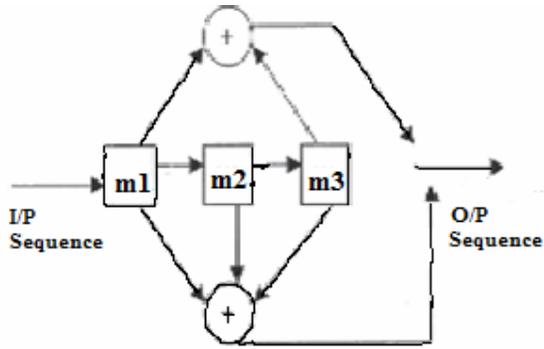


Fig-6

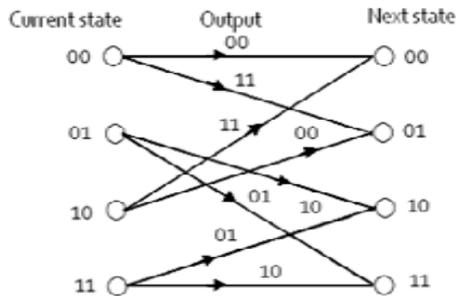


Fig-7 Code Trellis of Convolution Encoder

For decoding viterbi decoder is used. In viterbi decoding technique trellis diagram is used. Convolution codes are designed to take action on random independent error. Convolution error correcting coding technique implemented in simulink is shown in Figure-8.

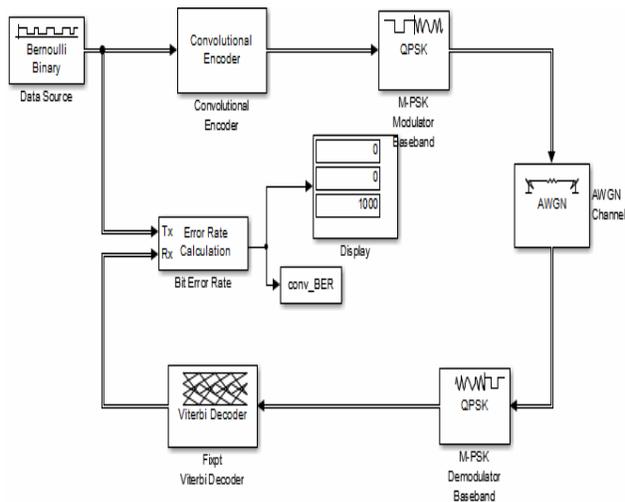
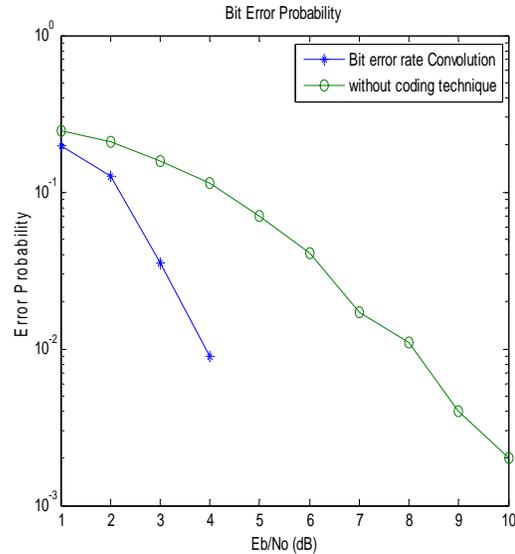


Fig-8

Comparative analysis of convolution coding technique and without coding technique is shown in Graph-5.

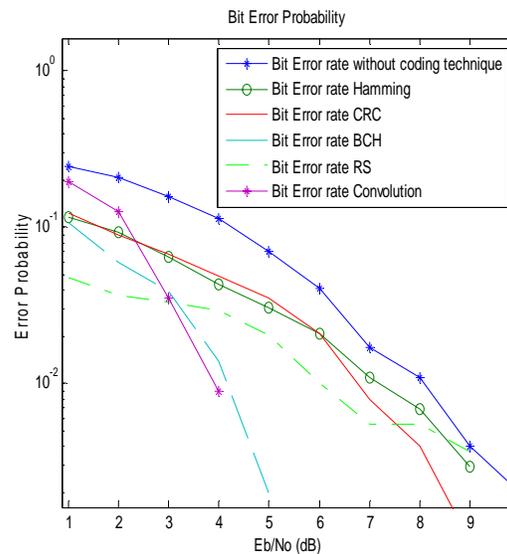


Graph-5

### VIII. COMPARATIVE ANALYSIS OF ALL ERROR CORRECTING CODING TECHNIQUES WHICH IMPLEMENT

In Error correcting coding techniques individual BER analysis with respect to without coding techniques is done. Without error correcting coding technique, BCH Coding, Hamming Coding, CRC Coding, Convolution Coding, RS Coding Technique comparative analysis of all these coding technique is shown in Graph-6 and Error probability at different SNR is shown in Table-I.

RS coding technique efficient for lower SNR, because error probability is very low compare other channel coding which are implemented in this paper.



Graph-6

TABLE I. COMPARATIVE ANALYSIS OF ERROR CORRECTING CODING TECHNIQUES

Eb/ No	Error Probability with Respect to 1000 Transmitted Bits					
	Without coding	BCH	Hamming	RS	CRC	Convolution
1	0.246	0.107	0.149	0.048	0.123	0.195
2	0.207	0.060	0.115	0.037	0.090	0.125
3	0.159	0.039	0.093	0.033	0.068	0.035
4	0.115	0.014	0.064	0.029	0.049	0.009
5	0.070	0.002	0.043	0.020	0.035	0
6	0.041	0	0.030	0.010	0.021	0
7	0.017	0	0.020	0.005	0.008	0
8	0.011	0	0.010	0.005	0.004	0
9	0.004	0	0.006	0.003	0.001	0
10	0.002	0	0.002	0	0	0

#### IX. CONCLUSION

After implementation of Channel coding techniques concludes that, RS coding technique is efficient whenever power limited channel used like Satellite Channel. Because if Eb/No is 1dB, 2dB, 3dB at that time error probability is lowest compare to BCH coding, Convolution Coding, CRC Coding, Hamming coding shown in Table-I. According to that RS coding technique is most efficient at lower SNR.

Convolution coding technique error probabilities become zero, when Eb/No is 5dB but at same Eb/No, 0.002 error probability present in BCH coding technique. But BCH coding technique not required memory component and memory component increase time delay, cost, complexity etc. In most of wireless communication technique BCH coding technique is used. After adding channel coding increases the signal quality on bursty channels [2].

This confirms the fact that by implementation of channel coding, we can improve the correction capability of codes. However this increases the complexity of the communication

system. But for reliable communication there must be some trade-off between system complexity and correction capability of the codes. Hence the objective of the research is successfully achieved in which this paper, success to analyse and simulates the performance of Channel coding using QPSK through AWGN channel.

#### X. FUTURE SCOPE

In future, this research can be extended by evaluating the performance of Source coding techniques with Channel coding techniques on Audio input signal.

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