Comparison of Channel Encoding Technique

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1. INTRODUCTION

The reliable and consistent transmission of data over a communication channel is faltered by a number of factors like noise, interference of signals, multipath etc. Hence we need a technique that takes care of these faults and the data at the receiver side is received correctly. There are a number of ways of correcting this, like retransmissions and error detection and correction. This helps in transmission of data in a correct and consistent manner. Among them the error detection and correction is preferably better as it consumes less time and power and it has less wastage of bandwidth. In this paper we will examine the comparison of the performance of various channel encoders on actual hardware.

KEYWORDS: BCH, RS, AWGN, Rician, codeword, multipath

ABSTRACT: The reliable and consistent transmission of data over a communication channel is faltered by a number of factors like noise, interference of signals, multipath etc. Hence we need a technique that takes care of these faults and the data at the receiver side is received correctly. There are a number of ways of correcting this, like retransmissions and error detection and correction. This helps in transmission of data in a correct and consistent manner. Among them the error detection and correction is preferably better as it consumes less time and power and it has less wastage of bandwidth. In this paper we will examine the comparison of the performance of various channel encoders on actual hardware.

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2. MATHEMATICAL MODELLING

2.1 BCH codes

BCH codes forms a class of random multiple error-correcting cyclic codes. For any positive integer \( m \geq 3 \) and \( t < 2^{m-1} \), [1, 2] there exists a binary BCH code with the following parameters:

Block length: \( n = (2^m) - 1 \)  
(1)

Number of parity-check digits: \( n - k \leq mt \)  
(2)

Minimum distance: \( d_{\text{min}} \geq 2t + 1 \).  
(3)

BCH codes are subset of the Block codes. In block codes, the redundancy bits are added to the original message bits and the resultant longer information bits called “codeword” for error correction are transmitted. The block codes are implemented as \( (n, k) \) codes where \( n \) indicates the codeword and \( k \) the original information bits.

2.2 RS codes

In coding theory, the Reed–Solomon [3] code belongs to the class of non-binary cyclic error-correcting codes. An RS code is a cyclic symbol error-correcting code:

\( \circ \) An RS codeword will consist of \( I \) information or message symbols, together with \( P \) parity or check symbols. The word length is \( N=I+P \).  
(4)

\( \circ \) The symbols in an RS codeword are usually not binary, i.e., each symbol is represented by more than one bit. In fact, a favourite choice is to use 8-bit symbols. This is related to the fact that most computers have word length of 8 bits or multiples of 8 bits.

\( \circ \) In order to be able to correct ‘\( t \)’ symbol errors, the minimum distance of the code words ‘\( D \)’ is given by \( D=2t+1 \).  
(5)

\( \circ \) If the minimum distance of an RS code is \( D \), and the word length is \( N \), then the number of message symbols \( I \) in a word is given by  
\[
I = N - (D - 1) \tag{6}
\]
\[
P = D - I. \tag{7}
\]

2.3 Bit error rate for different channel conditions
In a digital transmission, BER is the percentage of bits with errors divided by the total number of bits that have been transmitted, received or processed over a given time period. The rate is typically expressed as 10 to the negative power. The bit error probability $P_b$ often referred to as BER is a better performance measure to evaluate a modulation scheme. The BER performance of any digital modulation scheme in a slow flat fading channel can be evaluated by the following integral:

$$ P_b = \int_0^\infty P_{b,AWGN}(\gamma)P_{dF}(\gamma) \, d\gamma $$

(8)

Where $P_{b,AWGN}$ the probability of error of a particular modulation scheme in AWGN channel at a specific signal-to-noise ratio $\gamma = h^2 \frac{E_b}{N_0}$. Here, the random variable $h$ is the channel gain, $\frac{E_b}{N_0}$ is the ratio of bit energy to noise power density in a non-fading AWGN channel, the random variable $h^2$ represents the instantaneous power of the fading channel, and $P_{dF}(\gamma)$ is the probability density function of $\gamma$ due to the fading channel.

### 2.4 BER of BPSK modulation in AWGN channel

For coherent detection of BPSK:

$$ BER_{BPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) $$

(9)

where

$$ Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty \exp\left(-\frac{t^2}{2}\right) \, dt $$

(10)

### 3. RESULT AND ANALYSIS

#### 3.1 Methodology

The tool used for performing simulation of coding and decoding of Reed-Solomon and BCH codes through BPSK modulation scheme in AWGN channel was SIMULINK in MATLAB. The process is described as follows: $K$ random information symbols are input to the encoder for transmission. The encoder maps each of the input sequences to unique $n$ symbol sequence known as a codeword. The generated codeword is then passed to the next
module known as a digital modulator. The modulator uses modulation schemes like BPSK to modulate the data into signal waveforms.

3.2 Using awgn channel

![Comparison of SNR vs. BER for uncoded and BCH coded channel](image)

Figure 1: Comparative study of the graph for SNR vs. BER of uncoded channel and BCH coding with varying codeword length (n) and message length (k).

| Table 1 Variation of BER for uncoded and BCH coded channel for SNR=35dB |
|-----------------|-----------------|-----------------|
| Uncoded         | -               | BER=0.215       |
| BCH             | n=15, k=11      | BER=0.1557      |
|                 | n=31, k=11      | BER=0.122       |
|                 | n=511, k=10     | BER=0           |

From the above plot of SNR vs. BER it is observed that when the channel is uncoded the bit error rate tends to 0 after a certain value of SNR which is greater than that of the BCH coded channel. The BCH coding gives a less BER for a small value of SNR. This implies that the channel coding helps reduce the power consumption. With very less supply of power a better transmission is obtained with reduced BER.
Also it is observed that as the codeword is increased a better transmission is achieved, i.e., BER tends to 0 with small SNR value. This shows that as the redundancy is increased in the message length the BER reduces significantly with lesser power requirement.

![Graph showing SNR vs. BER for uncoded, BCH coded, and RS coded channels.](image)

Figure 2: Comparative study of the graph for SNR vs. BER of uncoded channel, BCH coded and RS coded channel with fixed codeword length (n) and message length (k).

<table>
<thead>
<tr>
<th></th>
<th>Uncoded</th>
<th>BCH</th>
<th>RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BER</td>
<td>0.215</td>
<td>0.2141</td>
<td>0.2778</td>
</tr>
</tbody>
</table>

Table 2: Variation of BER for uncoded, BCH and RS coded channel for SNR=-35dB

In this graph the uncoded channel transmission has been compared with coded channel transmission. The coding techniques that have been considered are BCH and RS. The codeword length and message length of both the coding techniques has been fixed, i.e., n=7 and k=4. Also the BCH coding is generally preferred over RS as the simplicity in coding with BCH is more than that of RS.

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Figure 3 Comparative study of the graph for SNR vs. BER for RS coded channel with varying codeword length (n) and message length (k).

Table 3: Variation of BER for RS coded channel of varying codeword length for SNR=35dB.

| n = 15, k = 11 | BER = 0.2302 |
| n = 31, k = 11 | BER = 0.2249 |
| n = 63, k = 7  | BER = 0.1994 |

This plot of SNR vs. BER shows the comparison among the curves obtained with varying codeword length and message length for Reed Solomon. The codeword lengths considered are 15, 31, 63 and the corresponding message lengths are 11, 11 and 7 respectively. It can be observed that with increase in codeword length a reduced BER with decreased SNR values is obtained respectively. This implies that with increase in redundancy the BER decreases with decreased requirement of power.

4. CONCLUSION

In the concerned paper for studying the performances of various channel coding techniques in order to minimise the error in a given system of communication two coding techniques...
techniques has been considered, i.e., BCH and Reed Solomon. The graph of BER vs. SNR has been obtained for each of the coding technique and compared.

Firstly, simulation using Simulink and also MATLAB has been done and the graph obtained has been shown. Comparing each of them it can be seen that coding is very much necessary for a transmission to be less erroneous. The comparison between uncoded and coded transmission has been obtained and at a less SNR a minimised BER for the coded transmission has been obtained. And also among all the different codeword length that has used it can be seen that a better channel performance is achieved in case of the greater codeword length. The closed loop has given a better performance than the open loop since the open loop is prone to more noise as it is wireless and is not shielded. Hence there is less chances of being effected by noise. From both the software and hardware results it can be seen that both the results are similar and hence the coding of the channel has been successfully implemented on the hardware.

REFERENCES