Implementation and Analysis of Convolutional Codes over AWGN Channel

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***Abstract*- Communication systems play a major role in our daily life; people use cell phones, satellites, internet, and data transmission. All these applications are used in an environment exposed to noise sources; also data might be transmitted for long distances. These effects could cause changes in data values causing data corruption and loss. This led to the introduction of channel coding to detect and correct transmitted data. The channel coding is the adding of redundancy bits to assure that errors can be detected and corrected successfully. The channel coding is divided into two main types Block codes and Convolution codes. Simulink modeling of convolutional encoders. The configuration covered modeling of configurable rate convolutional encoder with Viterbi decoder from a mother code rate of ½ to1/3 and 2/3 with constraint length 7. The modeling is done by changing rates of convolutional encoder and error of binary symmetric channel using simulink blocks.**

Index terms- Convolutional Encoders, AWGN Channels, Viterbi Decoder

I. INTRODUCTION

Communication systems play a major role in our daily life; people use cell phones, satellites, internet, and data transmission. All these applications are used in an environment exposed to noise sources; the main aim of a digital communication system is to transmit information reliably over a channel. The channel can be coaxial cables, microwave links, space, fiber optics etc, and each of them is subject to various types of noise, distortion and interference that lead to errors. Shannon proves that there exist channel-encoding methods which enable information to be transmitted reliably when source information rate R is less than channel capacity C. It is possible to design a communication system for that channel and with the help of error-control coding such as convolutional coding, one can achieve a very small probability of output error for that channel. Some forms of error control encoding that are used to recover some corrupted information are available. Convolutional coding is one of the channels coding extensively used for real time error detection.

This paper proposes the performance is analyzed in terms of Bit Error Rate (BER) and SNR by convolutional codes with the implementation aid of MATLAB over Additive White Gaussian Noise (AWGN) channel.

Convolutional decoders can use hard and soft decision decoding. Decoder inputs are continuous valued (or quantized values).Soft decision decoding gives a 2-3 dB gain over hard decision decoding. In this coding method, bit rate is increased and also it needs less power as compared with the block codes. Hence it helps to improve the transmission bandwidth. It is theoretically possible to approach the Shannon limit by using a block code with large block length or a convolutional code with a large constraint length. The processing power required to decode such long codes makes this approach impractical.

II. METHODOLOGY

A. Convoutional encoding

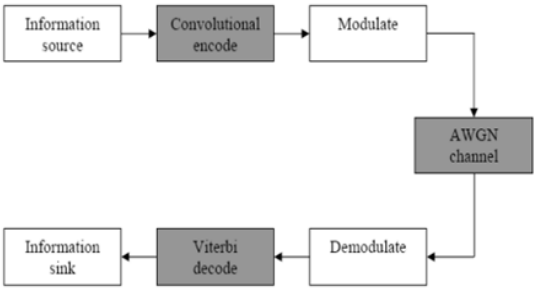

Figure. 1. Basic Communication System

As shown in Figure 1, the Basic communication system convolutional encoding is one way of performing channel coding. Another method uses

block codes. In these methods, redundant bits are used to help determine the occurrence of an error due to noise present in the channel. In the receiver
Viterbi decoding is a way of performing channel decoding. Convolution encoder is a type of error-correction method in which each m-bit information input in will be encoded to n-bit information symbol at the output. M/n is the code rate, and the transformation is a function of the k information symbol, k is the constraint length of the encoder. In Fig. 2, a simple convolutional encoder is shown. It has constraint length 3 and because two adders are used in it its rate is ½. A bit is shifted into the leftmost stage at each input and the bits previously existing in the shift registers are shifted one position to right. After applying the modulo-2 operation corresponding outputs are obtained. This process of continues until the arrival of data at the input of encoder.

The choice of connection between the shift registers and adders describes the characteristics of code. By varying the connections, characteristics of the code can be varied. Convolutional codes do not have a predefined word length like block codes [7]. These codes are being pushed into a frame structure by periodic truncation. Zero bits are appended in the message, for the sake of flushing the shift registers. Code rate may fall below k/n because of these added bits do not carry any information along with them. In order to stabilize the code rate, large truncation period is required. To describe an encoder, set of "m" connection vectors are required. These vectors have the same dimension as that of K (shift registers). These connections describe which shift register is connected with m adders. A value of "1" in the position demonstrates that, that shift register is connected to the adder and a „0" in given position will indicate that not a single connection exits between the stage and adder.

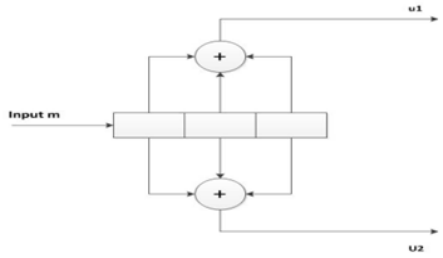

Figure. 2. Convolutional Encoder (Code Rate ½, Constraint length 3)

In a typical a Convolution Encoder with rate of ½ and constraint length of k=7, there are six memories to hold the bits input, at the beginning all the memory old the value of zero. There are two adders that combine the input data to product the output according to the arrangement of the designer.

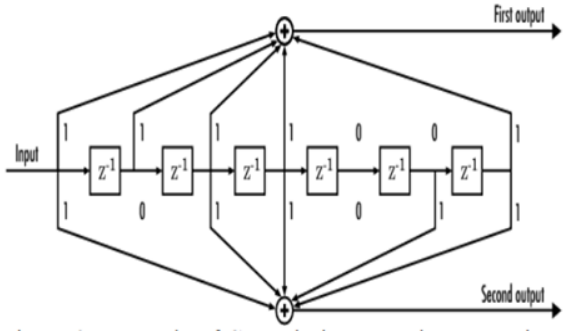

Figure 3: Example of Convolution Encoder constraint of 7

A. Modulation

The modulation technique used is Binary phase shift keying (BPSK) to map the 0"s and 1"s to antipodal baseband signal. For the modelling it is important to modulate either using The BPSK or QPSK because the signal will be transmitted with at least 5dB less power than when transmitting without modulation.

B. AWGN Channel

Every communication channel is exposed to different kinds of noise sources such as the Gaussian white noise (AWGN) it changes the value of the transmitted signal which might fluctuate the voltage around the threshold besides the attenuation of the signal in the long distances link. Those reasons cause some loss or changes in the data transmitted over the channel, the problem arise when you discover that the received data has been corrupted. Since it is known that AWGN channel embeds white noise to the signal that has been passed through it. The amount of noise in this channel is described by following quantities:

- Value of SNR for each sample. Value of SNR is the actual parameter of AWGN channel.
- Ratio of E_b/No and ratio of Es/No

We can define the relation between Eb/No and Es/No by following equation:

$$\frac{Es}{No}(dB) = \frac{Eb}{No}(dB) + 10log10(\mathrm{n})$$

Where bits per symbol are denoted by "n" [4]. This parameter may be influenced by the size of the

modulation alphabet and code rate of the error control code [5].

C. De-Modulation

This is the stage to recover the original message that was mapped to -1 and +1 back to the 0 and 1.

D. Viterbi Decoding Algorithm

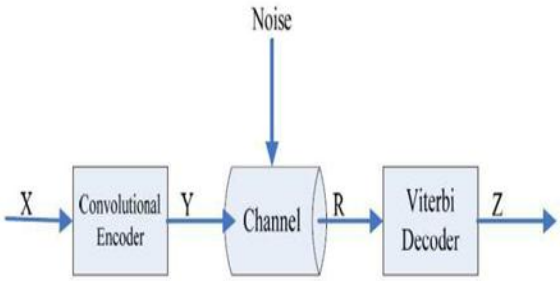

Figure. 4. simple Viterbi decoding system

This algorithm was devised and analyzed by Viterbi in 1967 .Basically, in this algorithm maximum likelihood decoding is performed. Maximum likelihood decoding is defined as process which decreases the computational load. It does so by taking the average of a particular structure in the code trellis. This algorithm has advantage over brute-force decoding in a way that the complexity is not defined in terms of the number of symbols in the encoded sequence.

The block diagram of the Viterbi decoder is shows below.

It consists of following blocks

a. Branch Metric Unit (BMU)

b. Path metric calculation

c. Add Compare and Select Unit (ACS)

d. Trace Back Unit (TBU)

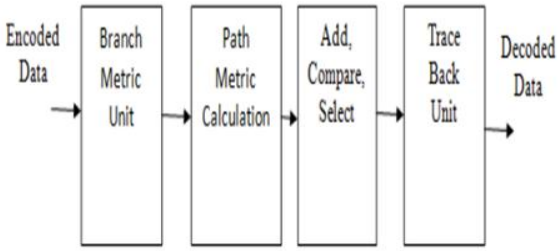

Figure. 5. Block diagram of the Viterbi decoder

III. RESULT

The result of the simulations of convolutional encoders using simulink is shown as belows,

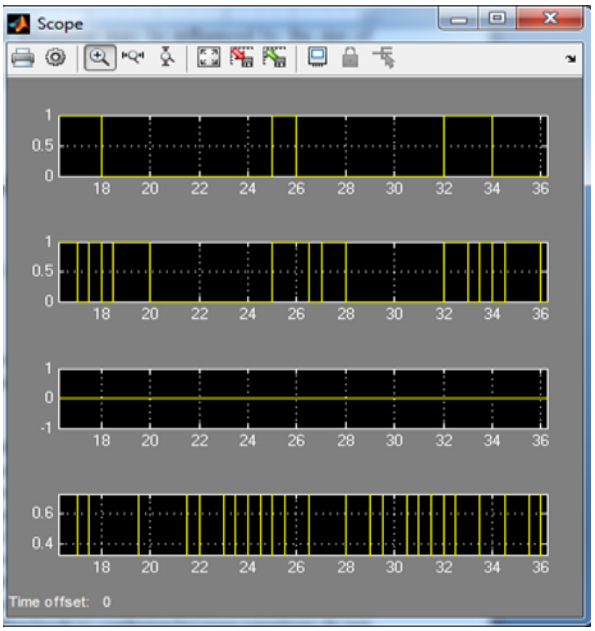

Figure 6: Simulation results by changing encoder with same BSC error

V. CONCLUSIONS

Simulation has done by using MATLAB .When signal to noise ratio changes the change in the output of convolutional encoder occurs. From the above results, it can be seen that by keeping signal to noise ratio constant and by changing data rates of convolutional encoder, rate 2/3 gives better result than 1/2 and 1/3.

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