



# DESIGN AND PERFORMANCE ANALYSIS FOR SATELLITE COMMUNICATION MODEL USING CONVOLUTION CODING TECHNIQUE

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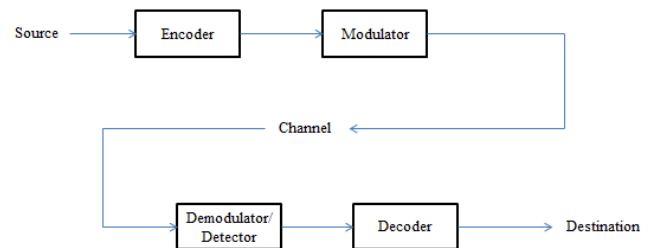
## ABSTRACT

In present world, communication has pervaded into the life of every individual and therefore lot of research is being done towards achieving a seamless, high speed and reliable communication between various users. Through satellite communication, transmission of data is easily possible for different users positioned at various locations. In satellite communication, forward error correction scheme will have great impact when channel is noisy. The error correcting scheme of convolutional codes will confide on constraint length and code generator. The convolutional encoder and viterbi decoder with an appropriate design will provide better performance. In this paper the performance analysis of a satellite communication model has been undertaken with Quadrature Phase Shift Keying (QPSK) modulation scheme along with convolutional coding technique having 1/2 and 1/3 rates. The performance has been analysed with different constraint lengths, in terms of Bit Error Rate (BER), with respect to the Signal to Noise Ratio (SNR) for Additive White Gaussian Noise (AWGN) channel. The simulation has been undertaken in MATLAB / Simulink.

**Keywords:** convolution code, BER, MATLAB Simulink, AWGN, constraint length.

## 1. INTRODUCTION

Satellite communication plays an important role in communication as the data can be easily transmitted to any place by utilizing a satellite orbiting around the earth. It does not depend on any terrestrial systems or lines to transmit the information so the deployment of signal is very speedy. So, compared to other communications, in satellite communication a signal can be easily transmitted or received over a wide area which is well beyond the line of sight. Now a day's highly conscientious data conveyance is hugely required in satellite communication [4] as errors may occur during transmission of data. Errors which are introduced in the information are due to interference, attenuation and channel noise. However, these errors can be reduced by using channel coding schemes. There are different types of coding schemes [5] and one of such coding schemes is convolutional coding scheme which is the most effective scheme to reduce the errors present in the information because of its capability to detect and correct the errors. In convolution coding encoding method redundancy is added in an organized manner to the information so that without requesting the source to broadcast the data again, the destination can correct the errors and these are also called as Forward Error Correction (FEC) scheme [6]. The satellite communication is used in many areas like deep space data transmission, mobile communication etc. The basic satellite communication model, which is shown in the Figure-1, consists of information source, coding, modulator, channel, demodulator, decoding and destination.



**Figure-1.** Basic Satellite Communication Model.

## 2. CONVOLUTION ENCODER

Convolution encoder [7] is a confined state device which has the memory of past inputs which dictates the number of states e.g. if there are 3 past inputs which are stored then the states are  $2^3$  i.e. 8. It is described by three parameters  $n, k, m$  where the term ' $n$ ' stands for number of output bits and ' $k$ ' signifies number of input message bits and ' $m$ ' indicates number of registers. The ratio of  $k/n$  is known as code rate ( $r$ ) which signifies the code efficiency. The parameter ' $L$ ' is called as constraint length [8] of the code and it is represented by  $L=k(m-1)$ . Constraint length is also represented sometimes by  $K$  which implies the encoder memory of the code.

### 2.1 GENERATOR POLYNOMIAL

The generator polynomial is defined as

$$g^{(i)}(D) = g_0^{(i)} + g_1^{(i)}(D) + g_2^{(i)}(D^2) + \dots + g_M^{(i)}(D^M)$$

Where

$D$  = unit delay variable

$M$  = number of shift registers

The generator polynomial signifies the connections of the encoder and it is also a mathematical



definition of convolution encoder. The block diagram of convolution encoder is shown in the Figure-2 represents the code rate of 1/2. It has three memory components. The modulo-2 adder is used for producing the output bits. From the Figure-2 it can be seen that the outputs are  $g(0) = (1\ 1\ 1)$  and  $g(1) = (1\ 0\ 1)$ .

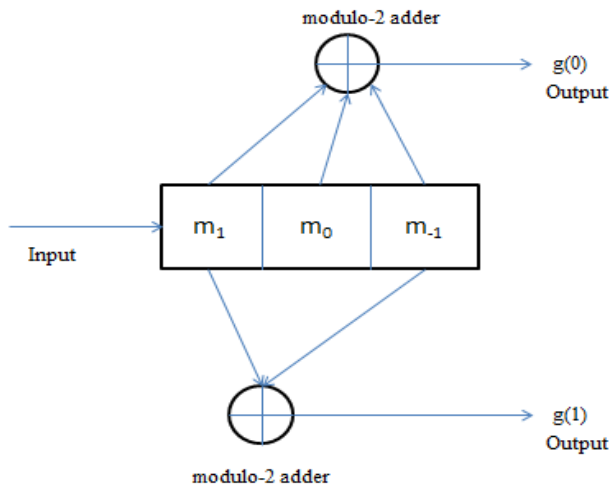


Figure-2. Block Diagram of Convolution Encoder.

## 2.2 POLY2TRELLIS

The syntax is:

`trellis = poly2trellis (constraint length, code generator)`

Poly2trellis takes convolution encoder's polynomial generator description and returns equivalent trellis. Both constraint length and code generator are the parameters required for poly2trellis function.

In order to decode the convolutionally encoded sequences, there are various methods; however Viterbi method is most popular amongst them as it supports trade-off among power consumption and complex hardware. Viterbi algorithm [1] was first developed in 1967 by Andrew Viterbi. Overall convolution encoder [9] combined with viterbi decoder provide good performance with relatively less complexity.

## 2.3 BIT ERROR RATE

During the transmission of information, the bits in the data get altered due to noise [11] etc. These are recovered back using the coding technique mentioned above; however there are still certain bits which are not recovered. The ratio of number of errors in the bit to the total number of bits transmitted over a communication channel is called as bit error rate (BER) [3]. It is generally expressed in percentage.

## 3. DESIGNED MODEL

The Figure-3 shows the model which is designed in SIMULINK/MATLAB software. The model employs AWGN channel and QPSK [10] modulation technique along with the convolution coding technique. The information transmitted from the source is encoded by convolutional encoder and then transmitted to the QPSK modulator for undertaking the modulation. The advantage

of using QPSK is, in a given bandwidth it can transmit twice the data rate than BPSK (binary phase shift keying). The information is then passed through simple AWGN channel [2] as there will be no loss of amplitude and no distortion of phase in the signal due to line of sight communication. In the channel there will linear addition of white noise with a constant spectral density. The information is then passed to the demodulator followed by viterbi decoder and finally at the destination BER is calculated. If the BER is less, then model is assumed to be working satisfactorily.

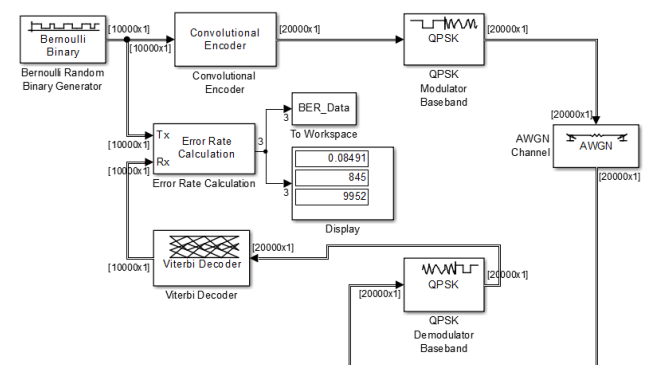


Figure-3. Simulink model with convolution encoder and viterbi decoder.

## 4. RESULTS AND PERFORMANCE ANALYSIS

In this paper, a convolution code based satellite communication model using MATLAB Simulink is shown in the Figure-3. The model has been tested for 1/2 and 1/3 code rates with different constraint lengths varying from 4 to 10 and the performance has been measured in terms of BER.

For the designed model, performance analysis i.e. BER versus  $E_s/N_0$  (signal to noise ratio) for code rate 1/2 with various constraint lengths is shown in the Figure-4 and with a code rate of 1/3 with various constraint lengths is shown in the Figure-5. From the graph in Figure-4, for coding rate 1/2 it is observed that at 10dB the BER is less than  $10^{-7}$ . However in Figure-5, for coding rate 1/3 it is observed that BER at 10dB  $E_s/N_0 = 10^{-7}$ .

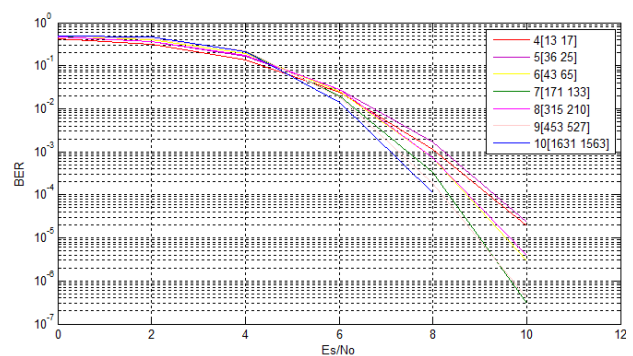
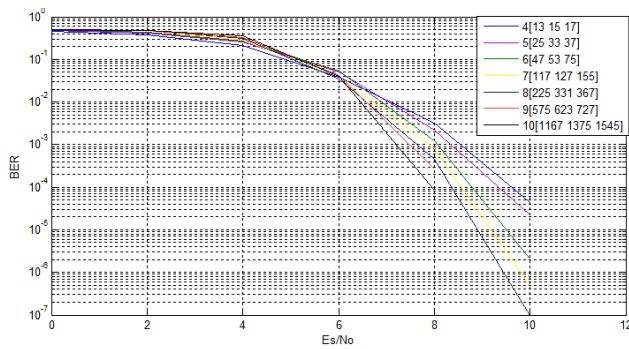


Figure-4. BER performance for code rate 1/2 with different constraint lengths.



**Figure-5.** BER performance for code rate 1/3 with different constraint lengths.

## 5. CONCLUSIONS

For the satellite communication model, it has been established that utilizing the convolution code enhances the BER because it is most efficient code compared to others as it can easily minimize the errors present in the data. In this coding technique various parameters like constraint length, code generator and code rate are suitably chosen so as to reduce the errors. This coding technique is crucial for reliable communication in satellites for a noisy channel. It is seen that for various generator polynomials, different BER values are observed. From the Figures 4 and 5 it can also be seen that if the constraint length increases for both the rates i.e. 1/2 and 1/3 then BER decreases in the latter case.

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