Channel Coding in Digital Communication

This aim of this mini-project is to study the role of channel encoder and decoder in digital communication. Convolutional Coding is used for encoding while Viterbi Decoder is used for decoding. Performance in terms of Bit Error Rate has been compared by developing two MATLAB based SIMULINK models, one uses channel coding while the other does not. For theoretical background relevant sections of chapters 6, 11 and 13 of the book ***Principles of Communication Systems, 3e by Herbert Taub, Donald L Schilling and Goutam Saha****.*

(**Acknowledgement** : The mini project is successfully completed under my guidance and the report is prepared by my PG. student, Mr. Sanjay K. Soni at IIT Kharagpur.)

I. INTRODUCTION

The input to this structure is the digital data (NRZ or RZ format). It could be either from the output of a computer or output of PCM encoder. This data stream is source encoded using any source encoding algorithm such as Lampel-Ziv or Huffman Algorithm. This source-encoded data is passed through channel encoder, which is used to combat the error that might occur in the channel. Channel encoder stage is followed by modulator stage (pass-band or base-band depending upon requirement). The output of modulator is transmitted into the channel that could be either base band (e.g. wire) or pass-band (e.g. free space). The received signal added with the noise is available at the input of demodulator stage where the signal is demodulated (i.e. converted into base band). The correlator output is passed through channel decoder such as Viterbi decoder.

II. BUILDING BLOCKS AND SETTING PARAMETERS IN SIMULINK:

Bernoulli Binary generator: Parameters are set as follows:

- Probability of zero is set to be 0.5 to ensure that 1 and 0 occur with equal probability.
- Initital seed = 61, sample time =1
- Frame based output active; sample per frame=1.

Convolutional Code:

- Use the MATLAB tool function poly2trellis (3, [5,7]) to design the trellis of convolutional encoder. Here, first input '3' shows the constraint length of encoder.[5,7] shows the polynomials for tap connection in octal number. Hence 5=[1 0 1], 7=[1 1 1].
- Reset= None

BPSK modulator:

- Phase offset =0
- Sample per symbol=1

AWGN channel:

- Initial seed =131 (different from that of Bernoulli generator
- Mode: Signal to noise ratio, Eb/N0
- Set Eb/N0 in dB
- Number of bits per symbol=1 (Because of BPSK)
- Input signal power=1 watte
- Symbol period=1s

BPSK Demodulator:

- Phase offset=0
- Sample per symbol =1

Viterbi Decoder:

- Trellis structure: poly2trellis (3, [5,7]).
- Decision type: Hard Decision if BPSK demodulator is used and 'Unquantized' if we are using Re (U) block to convert complex number from channel to real number to be fed to decoder directly without taking Hard decision.
- Trace back depth=96. It is the inherent delay of the decoder.
- Operation mode: Continuous.

Error Rate Calculation:

- Receive Delay: 96
- Computation Delay=0
- Computation Mode: Entire Frame
- Output Data= Port

Error Rate Display:

- Format: Short
- Decimation =1
- Sample time=-1

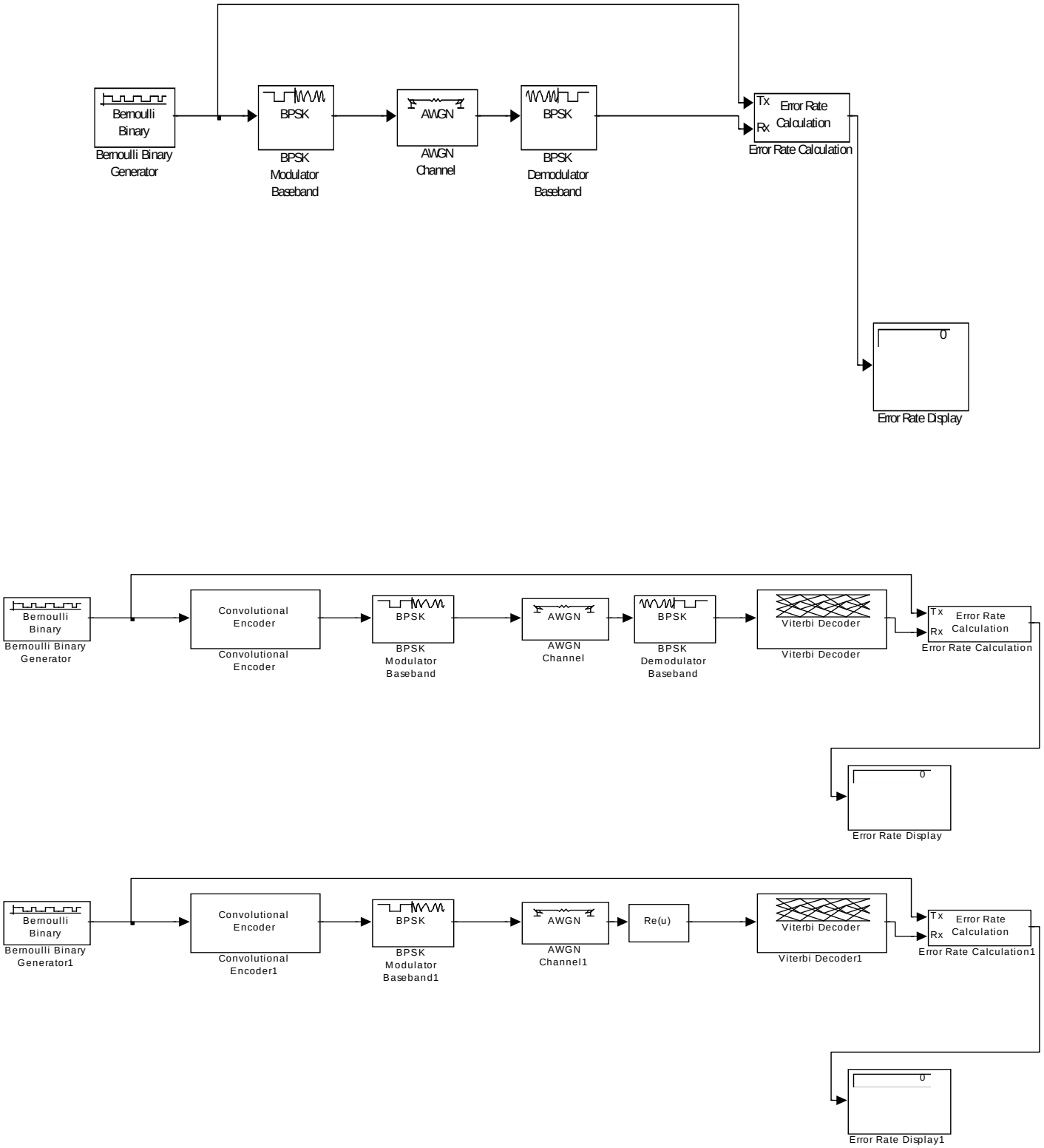

Fig 1: Simulink Model for Digital Communication System

III. RESULT AND DISCUSSION

Simulation result was carried out for 10,000 bits frame for different value of SNR. Firstly the theoretical result was obtained using the formula:

$$BER = 1/2 * \text{erfc}(\sqrt{Eb/N0})$$

Where Eb= Bit energy, N0/2= Variance of Noise

The basic system was set up using Simulink and BER result was obtained which is approximately same as the theoretical result. Next, channel encoder was incorporated into the system and Viterbi decoding was done for Hard decision input. Its performance improved over the uncoded system at higher SNR value. Next, soft input were taken which is nothing but channel output without quantizing it. This result for soft input showed much improvement over uncoded as well as coded but with hard decision input. Its explanation is that when soft input data is taken then we are not losing any information before hand thus Viterbi decoder gives better performance.