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STUDY TO INCORPORATE TURBO ENCODING TECHNIQUES IN DIGITAL TELEMETRY

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ABSTRACT

A simulation study has been done to analyse the performance of a Telemetry System with Turbo Coding. The design is in compliance with the Consultative Committee for Space Data System Standards. The transmitter of the communication system uses Turbo Encoding and BPSK modulation and the receiver comprises of a BPSK demodulator and a Turbo decoder. This system has been simulated with the help of Matlab, Simulink and Xilinx ISE. Various tests have been performed to evaluate the performance of the communication system and their results have been listed in this report.

I. INTRODUCTION

The aim of this project is to analyze the performance of Turbo Codes incorporated in Telemetry Systems. Data is to be transmitted to a Ground Station through space. The bit-rate of the data is 1Mbps. A suitable communication system is required to be able to transmit this data with as little error as possible and meet the timing constraints on the processing imposed by the bit-rate.

This PCM signal is to be transmitted through the space with a Bit Error Rate of less than 10^{-6}. The Signal to Noise ratio is assumed to 3dB at the receiver. The designed communication system transmits the PCM signal with required precision. The system employs Turbo Encoding and BPSK modulation to transmit the message while the received signal is appropriately demodulated and decoded to produce the message signal with an acceptable error. The Encoding is in compliance with CCSDS standards. The decoder of the receiver employs MAP decoding with the help of BCJR algorithm.

II. BLOCK DIAGRAM

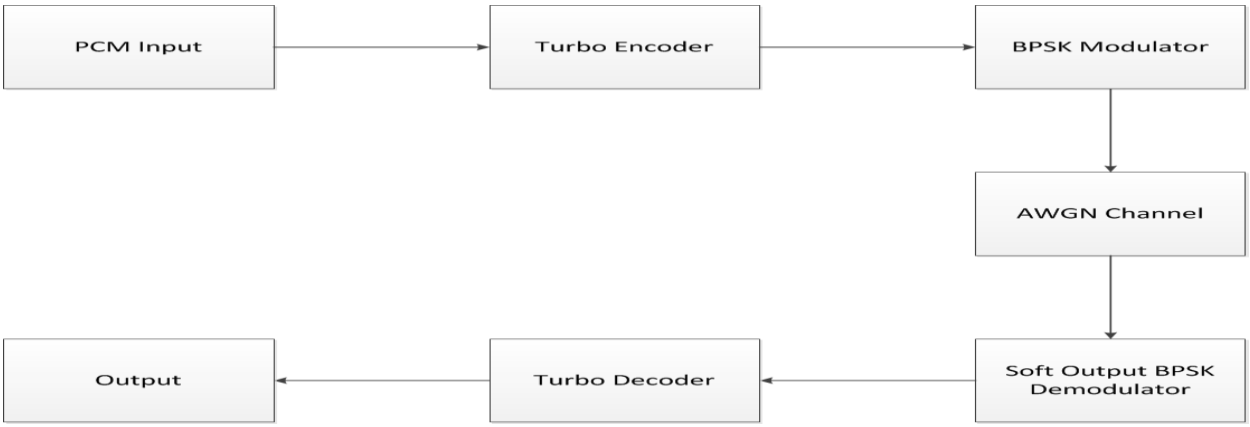

Figure 1: The Communication System

The difficulty with above systems is that, in an effort to approach the theoretical limit for Shannons channel capacity, the code-word length of a linear block code or the constraint length of a convolutional code has to be increased, which, in turn, causes the computational complexity of a decoder to increase exponentially. Ultimately, a point is reached where complexity is so high that it becomes practically unrealizable. Turbo codes are one of the few codes invented which perform very well and at the same time, have reasonable block lengths and constraint lengths.

A turbo encoder consists of two constituent systematic encoders joined together by means of an interleaver. The encoders used are Recursive Systematic Convolutional (RSC) Encoders, not necessarily the same. The interleaver permutes the code-word in a pseudorandom order which is an important requisite for a Turbo encoder.

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When properly decoded, this encoding scheme shows very good results which has been illustrated by the plot in Figure. The decoding is done using a Turbo decoder which is based on MAP or ML decoding. Max-log-MAP algorithm is used in most cases as it leads to important advantages. One of them is the simplicity in implementation since implementing max() is very simple. The other advantage is that it eliminates the dependency of the algorithm on the SNR. It can be observed that SNR factors out as a constant and does not affect the final hard decision of the Decoder. Thus, we can estimate the log-likelihood ratios for each input bit using the above algorithm.

III. SOFTWARE COMPONENTS

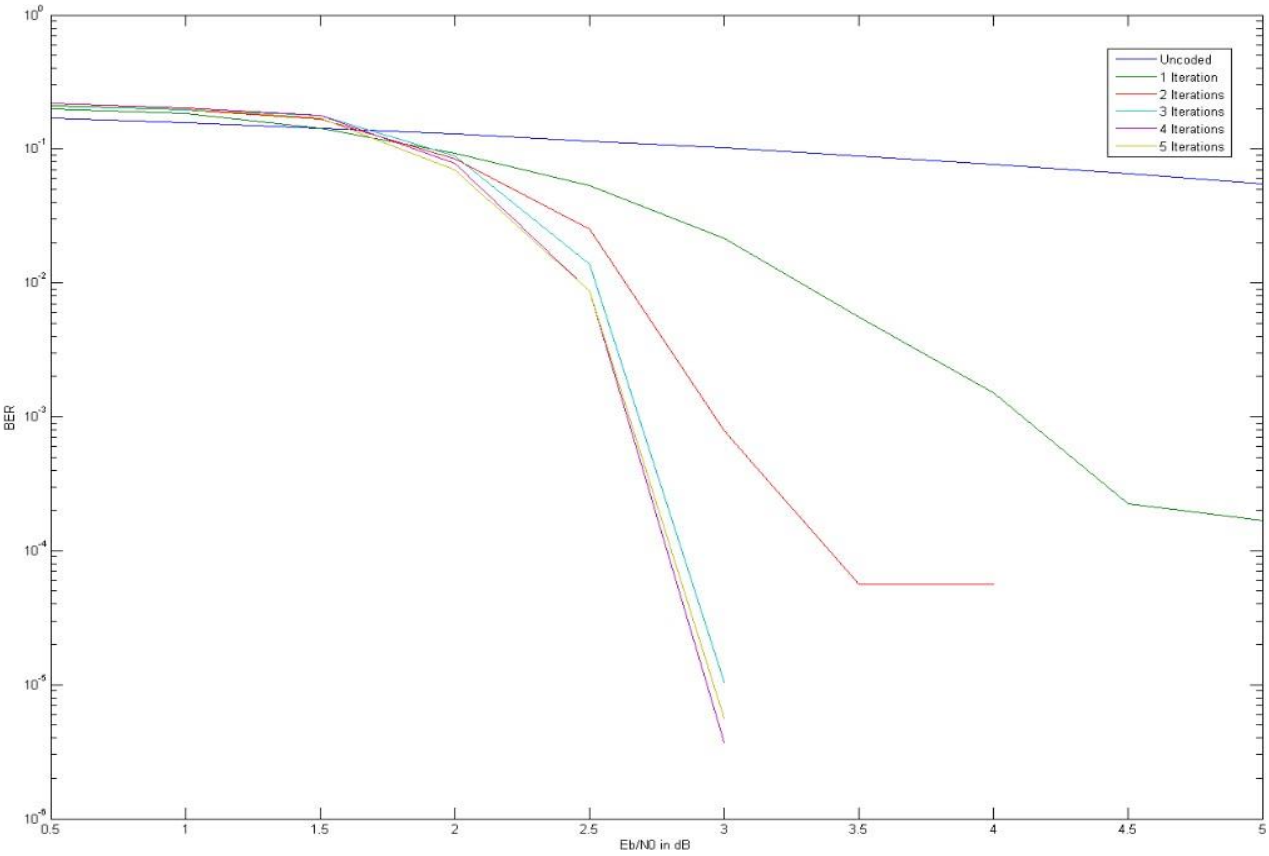
- MATLAB
- Simulink
- Xilinx ISE

Working

A block of 1784 bits is generated using the rand() function of Matlab. The probability of the occurrence of 0 and that of 1 is equally likely. Each block is processed individually. Such blocks are generated and processed repeatedly. This is equivalent to the generation of a random serial input. This block is encoded by a Turbo Encoder.

The Turbo Encoder has been implemented in Matlab and its constituent RSC encoders have been implemented in Simulink as a Simulink Model. The Turbo Encoder takes in the 1784 block input and produces a punctured code word of length 3576. The block is modulated using the BPSK modulation which has been implemented as function in Matlab. For the purpose of simulation, the frequency of the carrier wave is immaterial, provided the noise is white.

Thus, the BPSK modulator converts a 0 to -1 and 1 to +1. The awgn(signal, SNR) function of Matlab has been used to model the channel. The SNR argument is evaluated from the E_b/N_0 using the following expression. $R = 2\ Mbps$ is the code rate and $B = 5MHz$ is the Bandwidth of the channel.



IV. CONCLUSION

A simulation study was carried out to study the incorporation of Turbo Encoding techniques in Digital Telemetry. A substantial gain in the required E_b/N_0 has been observed in the Turbo Coded scheme as compared to that of the uncoded scheme.

Further study can be done on the Inter leaving algorithms. The Inter leaver is the key to the error performance of a Turbo Code. The performance of the system can be studied using various Interleaving algorithms, code rates and block lengths.

V. REFERENCES

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