

Abstract

The project here presents the essence of error free transfer of message between two nodes. To make the communication error free, Error Control and Coding (ECC) is used, which is achieved by using encoder and decoder pair(codec). Thus the work here is to concentrate on channel encoding and decoding techniques. Errors caused in the channel are because of AWGN (Additive White Gaussian Noise), multipath fading, interference and so on. So, to measure the errors BER(Bit Error Rate) is used, which is dependent on SNR(Signal to Noise Ratio). In first phase of the project channel coding techniques are tested for their performance with respect to BER, by simulating their models in Simulink and BERTool. And in next phase channel coding techniques are simulated in Xilinx and ModelSim, by preparing the verilog codes and these codes are made to run on FPGA.

Introduction

Communication

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- Transfer of Data in a medium

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- Transfer of Data in a medium
- Transmission Channel

Introduction

Communication

- Transfer of Data in a medium
- Transmission Channel
- Data Corruption

Introduction

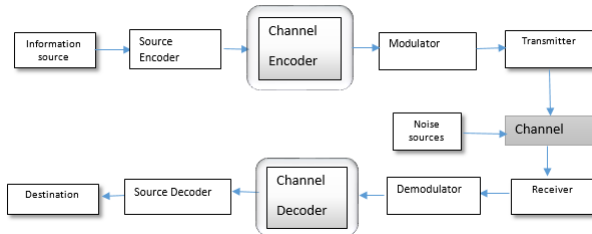


Figure: Block Diagram of Communication System

Introduction

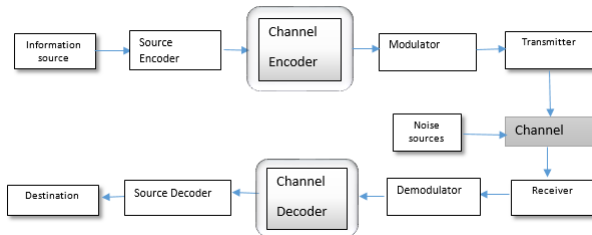


Figure: Block Diagram of Communication System

- Channel Encoder Decoder Pair

Introduction

Channel Coding

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Channel Coding

- Inevitable Existence of Errors on any given Communication Channel

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Channel Coding

- Inevitable Existence of Errors on any given Communication Channel
- Channel Noises

Error Control and Coding

Error Control and Coding

- Detection and Correction of Codes

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- To Achieve Reliable Communication

Error Control and Coding

- Detection and Correction of Codes
- To Achieve Reliable Communication
- Types of Error Correction Mechanisms

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- Types of Codes
 - Block Codes
 - Convolutional codes

Error Control & Coding

Hamming Codes

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- First Class of Linear Block Codes

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- FEC Achieved by Using Parity Bit Mechanism

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- Table Driven Decoding

Error control & Control

Hamming Codes

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Hamming Codes

- (n,k) Hamming Code

Error control & Control

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- (n,k) Hamming Code
- Code length: $n=2^m - 1$
- No. of information symbols: $k=2^m - m - 1$
- $m \geq 3$: Hamming Distance= $n-k$

Error control & Control

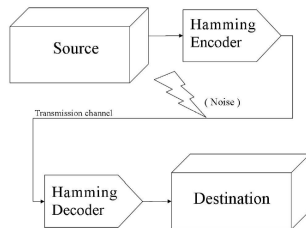
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Error Control & Coding

Convolutional Codes

- Non Linear Block Codes
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- Employs Trellis Structure

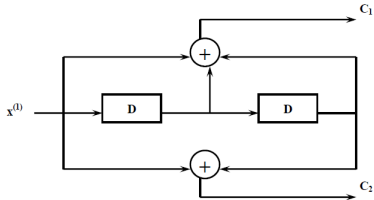
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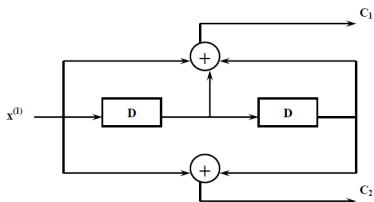
Error Control & Coding

Convolutional Codes



Error Control & Coding

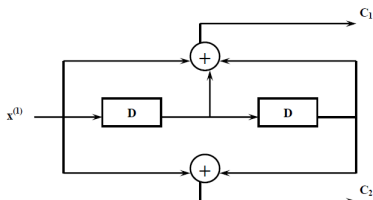
Convolutional Codes



- (n,k,m) Convolutional Codes

Error Control & Coding

Convolutional Codes



- (n,k,m) Convolutional Codes
- no of input bits k
- no of encoded bits n
- memory order m
- code rate = k/n

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Viterbi Decoding

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Viterbi Decoding

- Maximum Likelihood Decoding Algorithm

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 - Maximum Likelihood Path(Codeword)

Error Control & Coding

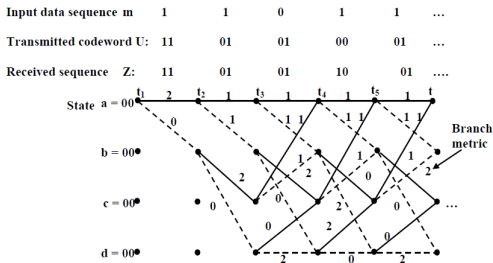
Viterbi Decoding

- Maximum Likelihood Decoding Algorithm
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Error Control & Coding

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 - Bit Metrics



Tools Used

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- **Software Tools**
 - MATLAB

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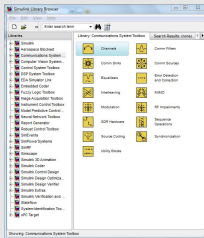
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Software Tools Used

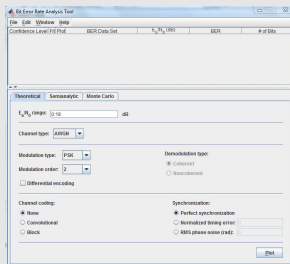
Simulink



- Graphical Programming Environment
- Libraries of Functional Blocks
- Model Analysis Tools
- Generating Code(C,C++,HDL)

Software Tools Used

BER Tool



- Bit Error Rate Analysis
- Theoretical Simulation
- Monte-Carlo Simulations

Software Tools Used

XILINX

The screenshot displays the Xilinx IDE interface. The 'Design Summary' window is open, showing project details for 'Hemmingcode'. The 'Design Overview' pane on the left lists various reports and messages. The 'Design Summary' pane on the right contains two tables: 'Hemmingcode Project Status' and 'Design Utilization Summary'.

Hemmingcode Project Status (05/11/2015 - 23:28:52)			
Project File:	Hemmingcode.xise	Implementation Status:	Synthesized
Module Name:	hem	Errors:	No Errors
Target Device:	xc7s400-3sp200	Warnings:	8 Warnings
Product Version:	ISE 15.1	Routing Results:	
Design Goal:	Balance	Timing Constraints:	
Design Modeling:	After Default (Unlocked)	Final Timing Score:	

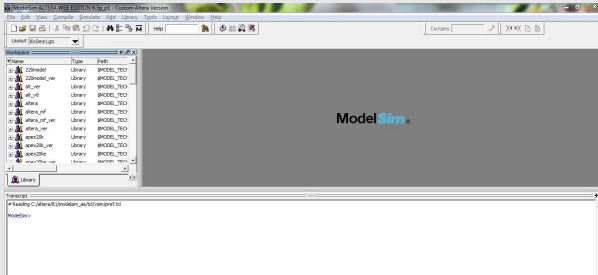
Design Utilization Summary (estimated values)			
Logic Utilization	Used	Available	Utilization
Number of Slices	7	2594	0%
Number of Input/Output Blocks	13	7350	0%
Number of bonded I/Os	26	340	10%

Detailed Reports				
Report Name	Status	Generated	Errors	Warnings
synthesis_report_1	Current	Sun 11 May 23:28:52 2015	0	8 Warnings
synthesis_report_2				
synthesis_report_3				
synthesis_report_4				
synthesis_report_5				
synthesis_report_6				
synthesis_report_7				
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- HDL Design Analysis and Synthesis
- Integration With ModelSim
- Behavioural Verification
- FPGA Synthesis

Software Tools Used

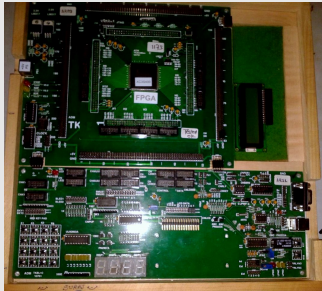
ModelSim



- Implements Verilog and System Verilog Languages
- Test Bench Development

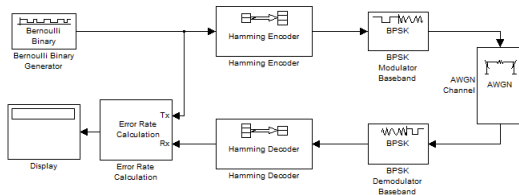
Hardware Tools Used

FPGA



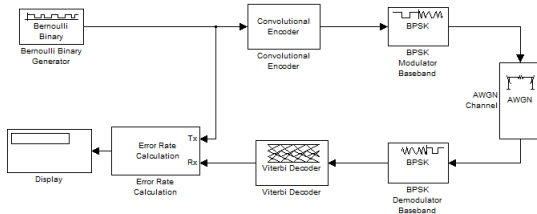
- Contains an array of programmable logic blocks.
- Netlist can be generated.
- It has a serial interface called JTAG.

Implementation of Hamming Codes



- Hamming code:(7,4)
- Modulation: BPSK
- Channel:AWGN

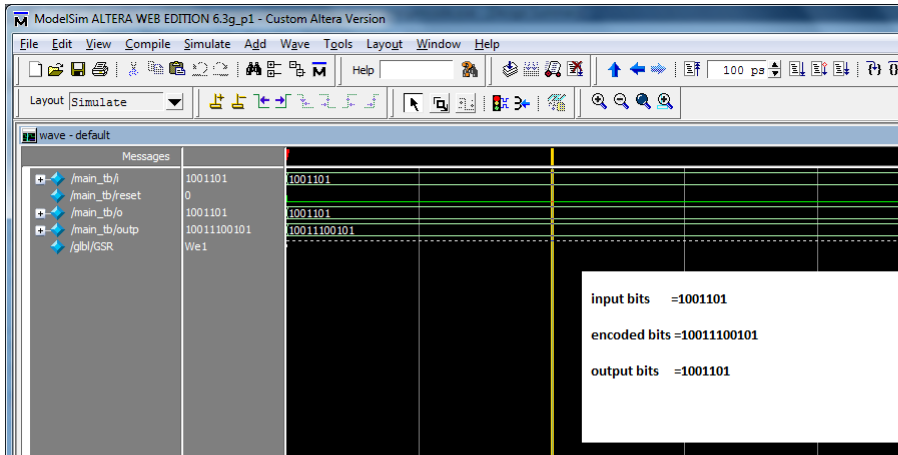
Implementation of Convolutional Codes



- Convolution code : $(7, [171 \ 133], 171)$
- Modulation: BPSK
- Channel: AWGN

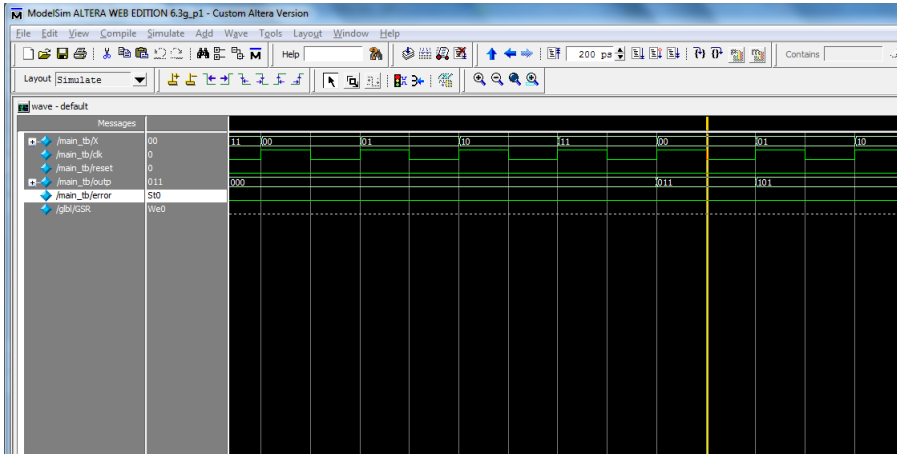
Results and Discussions

Simulation Results of Hamming Codes



Results and Discussions

Simulation Results of Convolutional Codes



Results and Discussions

Comparative Analysis of BER for Hamming and Convolutional Codes

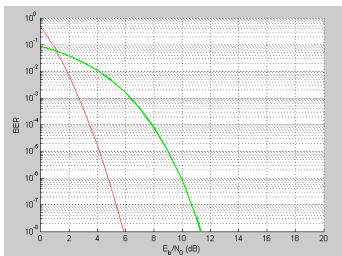


Figure: where, Green-Hamming and Red-Convolution

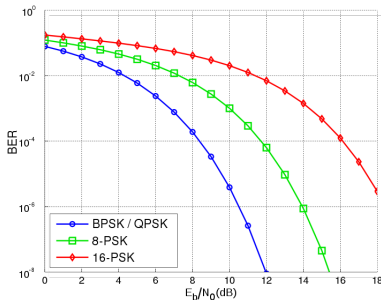
E_b/N_0	Hamming	Convolutional
1	0.149	0.195
2	0.115	0.125
3	0.093	0.035
4	0.064	0.009
5	0.043	0
6	0.030	0
7	0.020	0
8	0.010	0
9	0.006	0
10	0.002	0

Figure: BER values of Hamming and Convolutional Coding

- X-axis: E_b/N_0 , Y-axis: BER
- Modulation: BPSK, Channel Model: AWGN

Results and Discussions

BER Comparison for Modulation Techniques



- In a limited bandwidth channel, BER increases with the bit rate.
- BER of BPSK and QPSK are almost same.
- BPSK is chosen for the simplicity in circuit.

Conclusion

- BER and SNR Inversely Proportional
- The Simulation Results Show Convolutional Codes Perform Better Than Hamming Codes
- BER is Dependent on Modulation Techniques

Future Scope

- The Work Can be Further Extended on Rayleigh and Ricean Channel Models
- Constructing Adaptive Channel Encoder and Decoders
- SDR - Software Defined Radio

References



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Jayshree S. Nandaniya,Nilesh B. Kalani,Dr.G.R.Kulkarni. "*Comparative Analysis of Different Channel Coding Techniques*",IRACST International Journal of Computer Networks and Wireless Communications (IJCNCW), vol.4,No.2,April 2014.



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