Transmission of Audio Files using Random Codes Based on Quasigroups

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Outline

Introduction

- Transmission of audio files through a binary-simetric channel
- Coding/Decoding algorithms: Cut-Decoding and 4-Sets-Cut-Decoding
- Code $(72, 576)$ with rate $R = \frac{1}{8}$
- Experiments with Beethoven's "Ode to Joy"
- Analyzing the results

Random Codes Based On Quasigroups

- Combination of coding/decoding and encryption/decryption algorithms
- The algorithms are using the alphabet of nibbles $Q = \{0, 1, ..., 9, a, b, c, d, e, f\}$
- The message that needs to be transmitted is structured in a packets of 18 nibbles
- Packet-error rate:

$$PER = \frac{\#(incorrectly\ decoded\ packets)}{\#(all\ packets)}$$

- Bit-error rate:

$$BER = \frac{\#(incorrectly\ decoded\ bits\ in\ all\ packets)}{\#(bits\ in\ all\ packets)}$$

Outline

Cut-Decoding Algorithm

- Modification of the standard RCBQ algorithm for better performances
- 4.5 times faster than the standard one
- Detailed description of the algorithm is given in **??**

Outline

4-Sets-Cut-Decoding Algorithm

- Modification of the Cut-Decoding algorithm
- Increasing the coding and decoding speed
- Detailed description of the algorithm is given in []

Outline

Representing Audio Files

- Sequence of samples and sampling rate
- Samples are values in range $[-a, a]$ where a can be power of 2
- Sample rate is the number of samples of audio carried per second, measured in Hz

Outline

Converting Audio File to Nibbles

- Using Matlab function *audioread*$[y, F_s]$
- y is the sequence of sample values, F_s is the sample rate
- Converting sample values to 32-bit integer numbers
- Adding 32768 on every sample value
- Converting every sample value to a four digit hexadecimal number
- Creating messages as a sequence of 18 hexadecimal digits

Outline

Converting Nibbles to Audio File

- Using Matlab function *audiowrite*$[y, F_s]$
- y is the sequence of sample values, F_s is the sample rate
- Dividing the output in a 4 digit hexadecimal numbers
- Converting 4 digit hexadecimal numbers to integers and subtracting 32768

Outline

Original Audio

Beethoven‘s Ode to Joy

- Beethoven‘s Ode to Joy
- Total number of packets:43008
- Total number of bits: $43008 * 18 * 4 = 3096576$

Outline

Cut-Decoding Algorithm

Probability of Error $p = 0.05$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.05$

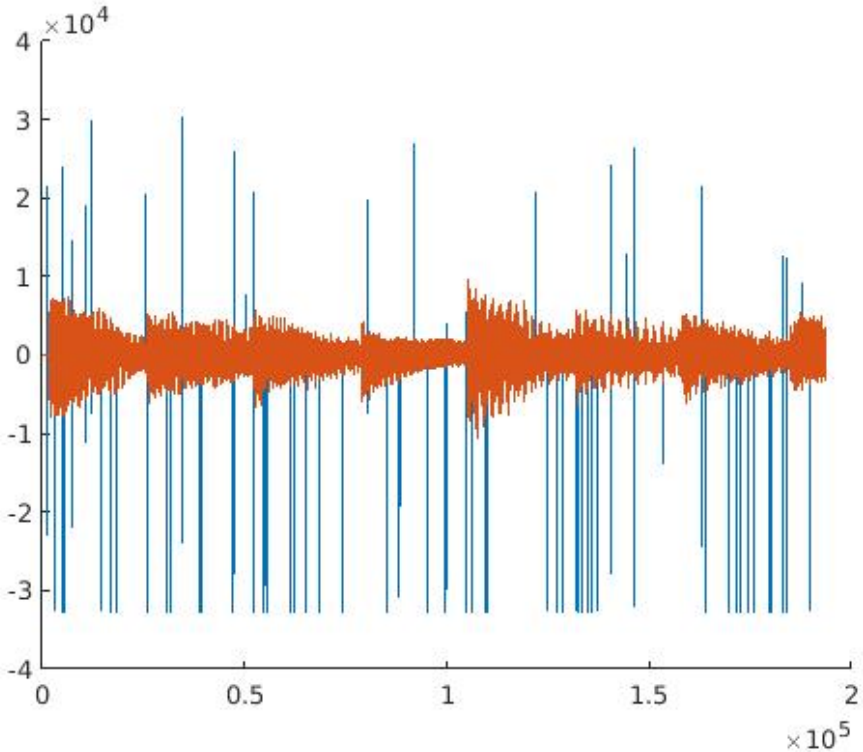


Figure: Difference for $p = 0.05$

Cut-Decoding Algorithm

Probability of Error $p = 0.08$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.08$

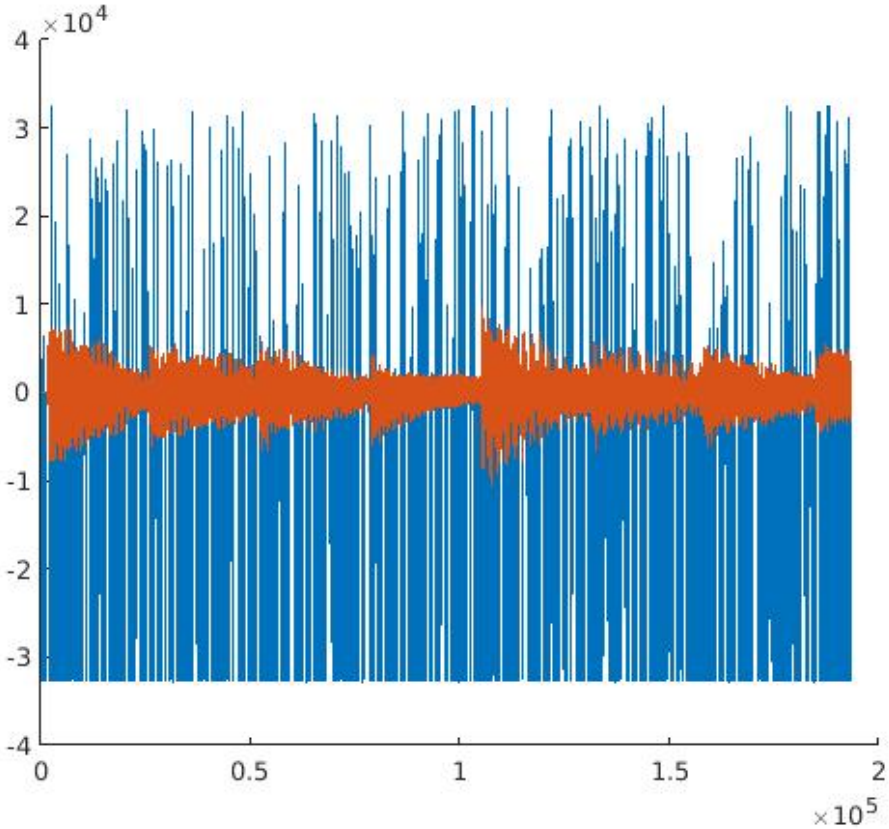


Figure: Difference for $p = 0.08$

Cut-Decoding Algorithm

Probability of Error $p = 0.11$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.11$

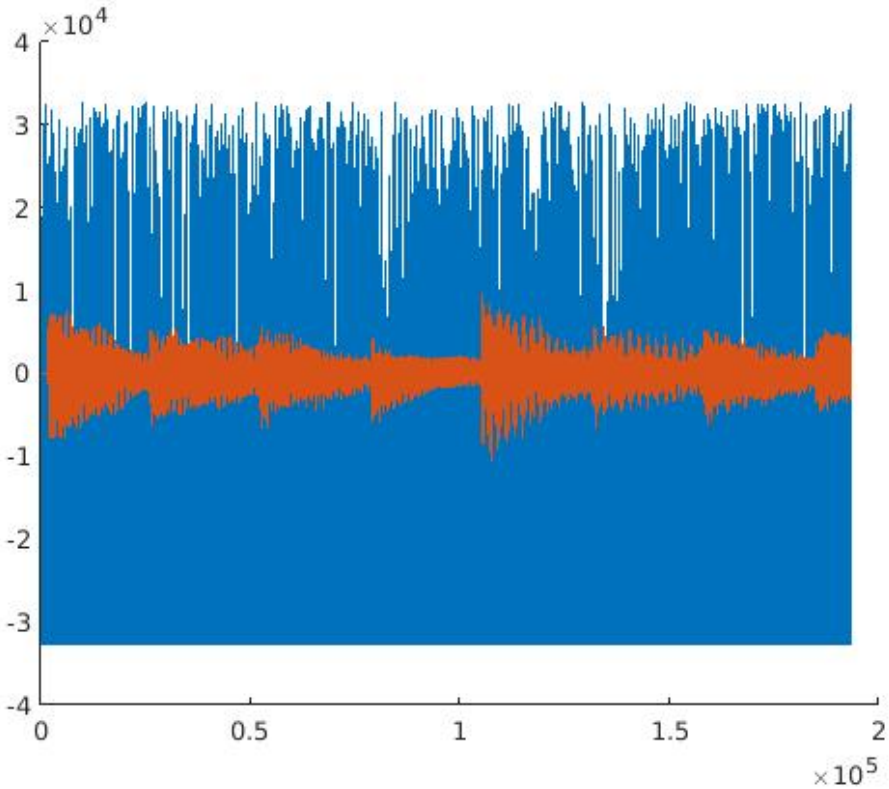


Figure: Difference for $p = 0.11$

Cut-Decoding Algorithm

PER and BER

- Table of experimental results for *PER* and *BER*

p	*PER*	*BER*
0.05	0.001697359	0.000913267
0.08	0.023111979	0.011926399
0.11	0.113071987	0.057805137

Table: Experimental Results using Cut-Decoding

Outline

4-Sets-Cut-Decoding Algorithm

Probability of Error $p = 0.05$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.05$

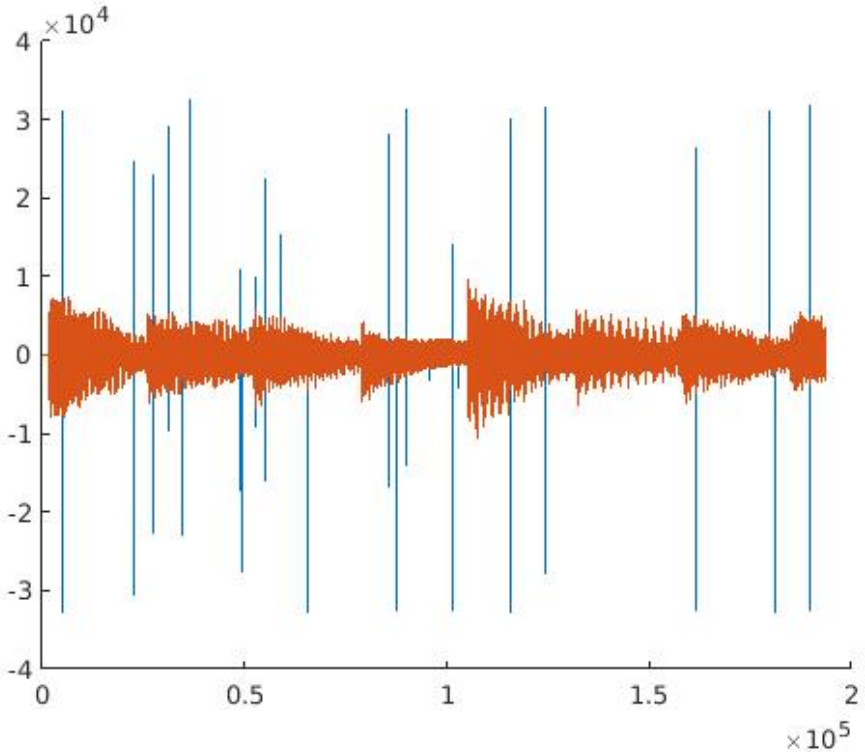


Figure: Difference for $p = 0.05$

4-Sets-Cut-Decoding Algorithm

Probability of Error $p = 0.08$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.08$

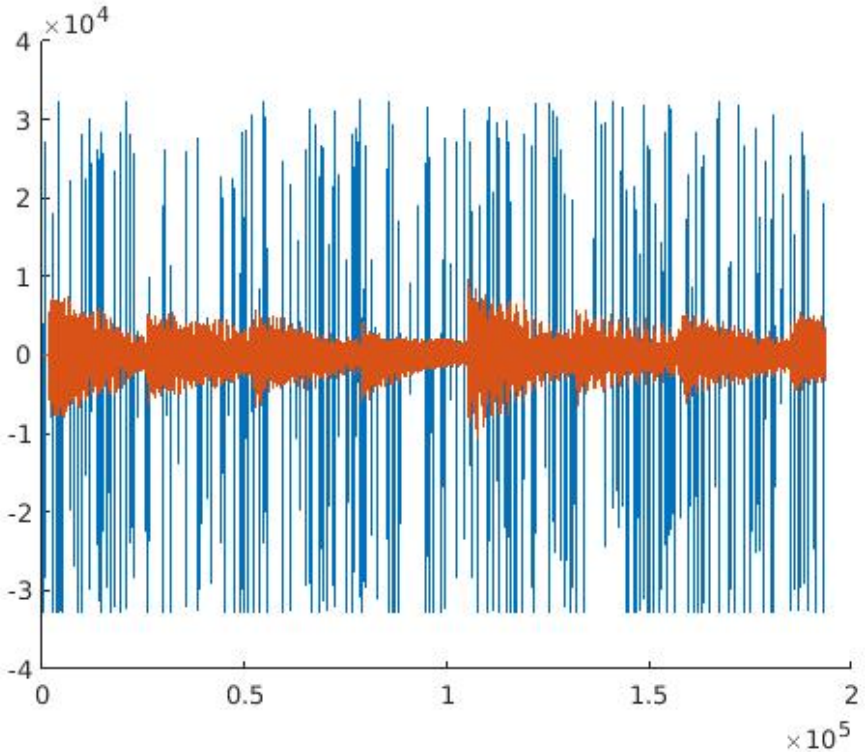


Figure: Difference for $p = 0.08$

4-Sets-Cut-Decoding Algorithm

Probability of Error $p = 0.11$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.11$

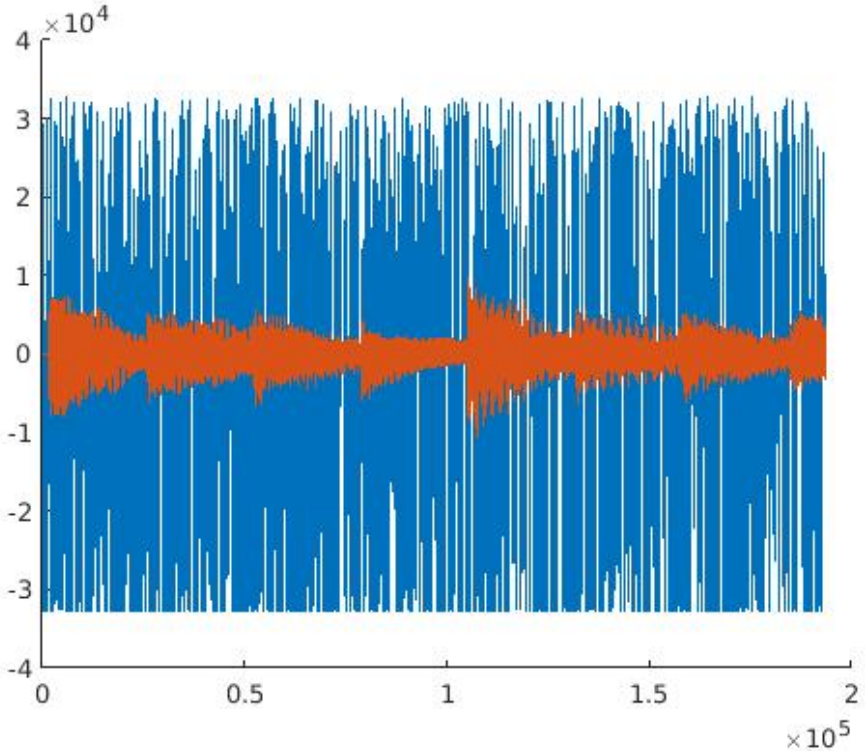


Figure: Difference for $p = 0.11$

4-Sets-Cut-Decoding Algorithm

Probability of Error $p = 0.14$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.14$

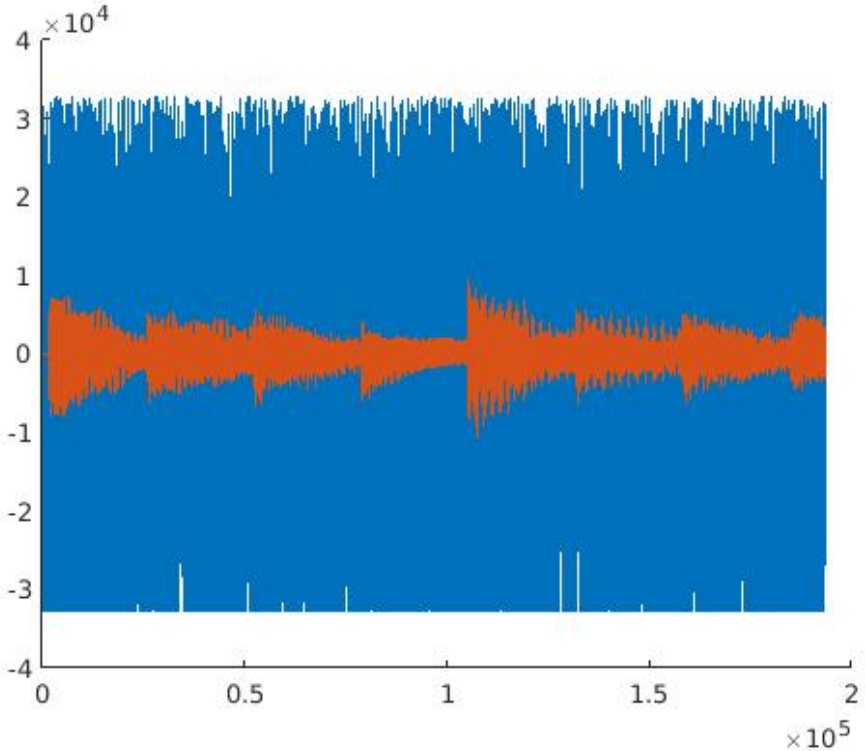


Figure: Difference for $p = 0.14$

4-Sets-Cut-Decoding Algorithm

Probability of Error $p = 0.17$

- Difference between the original(orange colored) and transmitted(blue colored) audio file for $p = 0.17$

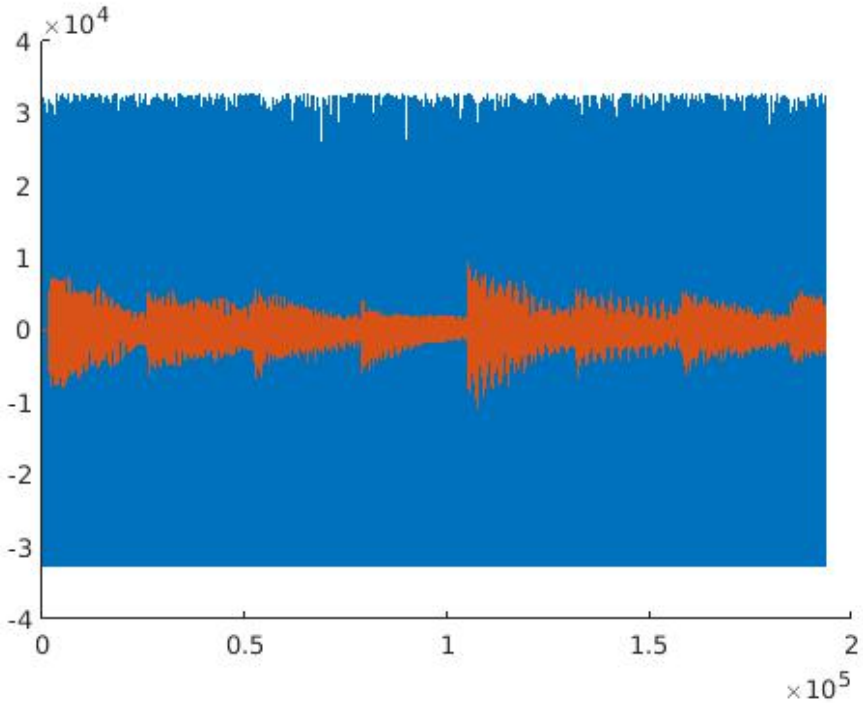


Figure: Difference for $p = 0.17$

4-Sets-Cut-Decoding Algorithm

PER and BER

- Table of experimental results for *PER* and *BER*

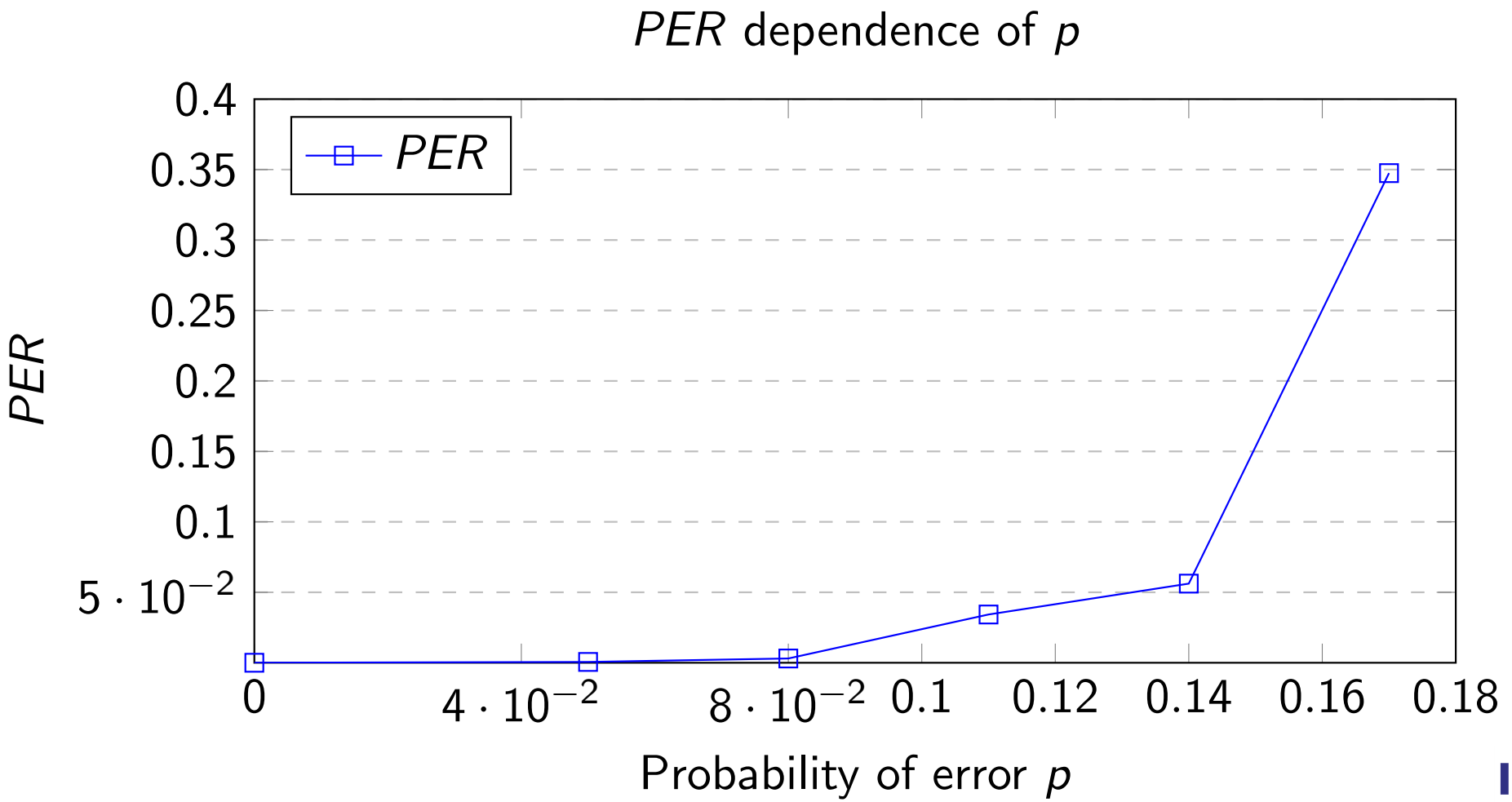
p	*PER*	*BER*
0.05	0.000581287	0.00026061
0.08	0.007091704	0.003033027
0.11	0.034249442	0.015375047
0.14	0.129580543	0.056156219
0.17	0.34749349	0.153494376

Table: Experimental Results using 4-Sets-Cut-Decoding

4-Sets-Cut-Decoding Algorithm

PER and BER

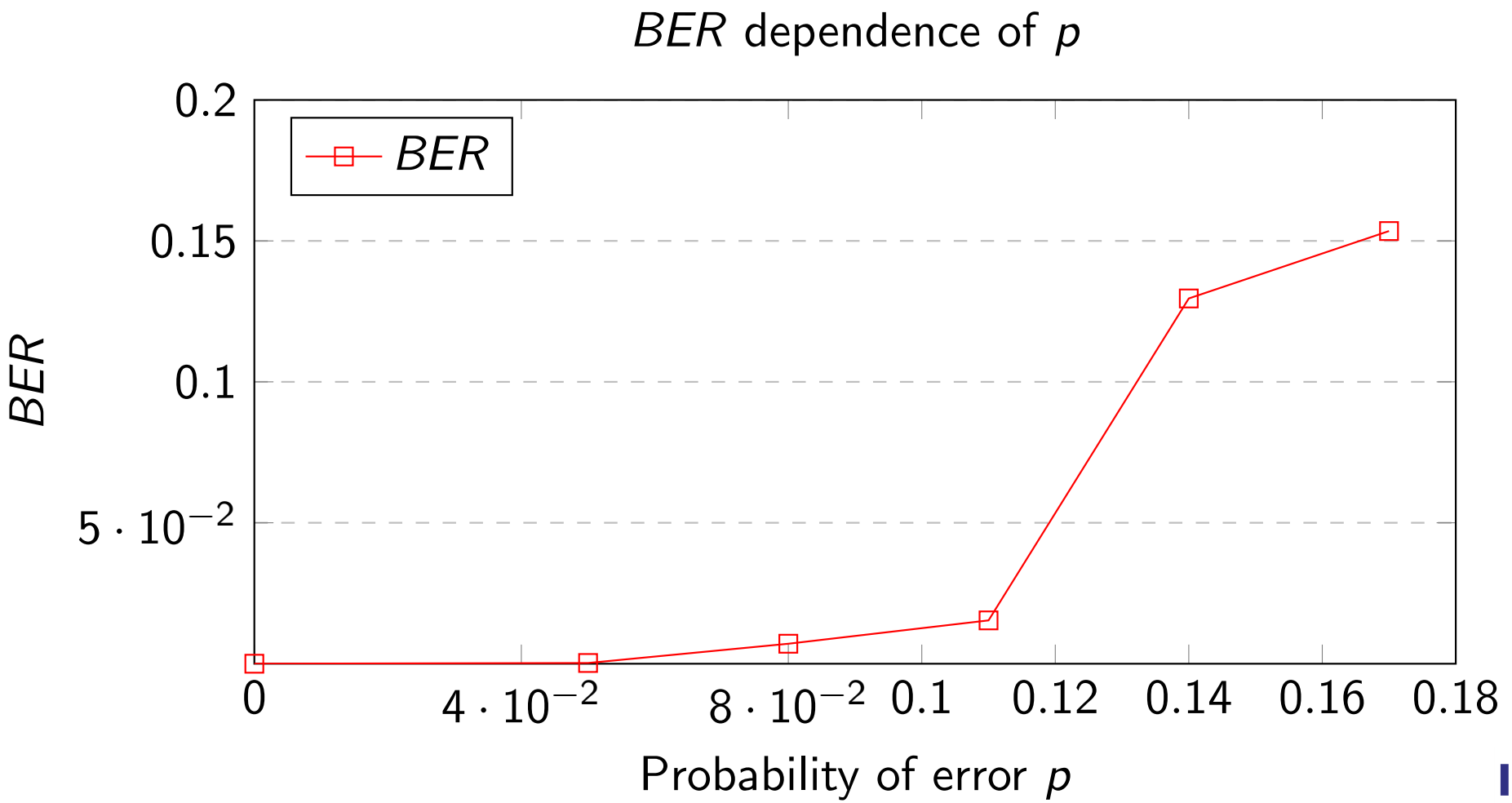
- Plot of experimental results for *PER*



4-Sets-Cut-Decoding Algorithm

PER and BER

- Plot of experimental results for *BER*



For Further Reading I

A. Author.
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Some Press, 1990.

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On this and that.
Journal of This and That, 2(1):50–100, 2000.