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# شبكة المعلومات الجامعية التوثيق الالكتروني والميكرو فيلم





# جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

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بالرسالة صفحات  
لم ترد بالأصل





**AIN SHAMS UNIVERSITY  
FACULTY OF ENGINEERING**

**Electronics Engineering and Electrical Communications**

# **Study on Spatial Multiplexing Techniques in MIMO Systems**

A Thesis Submitted for the Fulfillment of the Requirement of Master Degree  
In Electronics Engineering and Electrical Communications

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## **STATEMENT**

This thesis is submitted as a partial Fulfillment of Master of Science, In  
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The Author carried out the work included in this thesis and no part of it has been  
submitted for a degree or a qualification at any other scientific entity

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## **Contents**

<b>Abstract</b> .....	7
<b>List of Figures</b> .....	8
<b>List of Abbreviations</b> .....	10
<b>List of Symbols</b> .....	11
<b>Chapter 1: Introduction</b> .....	13
1.1 Introduction.....	13
1.2 LTE Design Principles.....	18
1.3 LTE Specifications .....	21
1.3.1 OFDMA and SC-FDMA .....	21
1.3.2 MIMO.....	23
1.4 Fifth generation Design Principles .....	23
1.5 Fifth generation Specifications .....	24
<b>Chapter 2: Introduction to MIMO Systems</b> .....	26
2.1 Introduction.....	26
2.2 MIMO Diversity Techniques.....	27
2.2.1. Transmit Diversity.....	28
2.2.2. Receive Diversity.....	29
2.3 MIMO Spatial Multiplexing Technique.....	29
2.4 Advantages of MIMO Systems .....	30
2.4 MIMO System Model.....	30

<b>Chapter 3: Detection Techniques for Spatial Multiplexing MIMO System .....</b>	<b>31</b>
3.1 Spatial Multiplexing MIMO .....	31
3.2 Optimal Detection Technique .....	32
3.3 Linear Detection Techniques.....	33
3.3.1 Zero Forcing .....	34
3.3.2 Minimum Mean Square Error (MMSE).....	34
3.4 Non Linear Detection Techniques .....	35
3.4.1 Successive Interference Cancellation (SIC) .....	35
3.4.2 QR Decomposition Detection Techniques .....	37
<b>Chapter 4: Tree Search Detection Technique .....</b>	<b>42</b>
4.1 Sphere Decoding Detection Techniques .....	42
4.1.1 Sphere Decoding Algorithm.....	43
4.1.2 Sphere Decoding Search Strategies.....	44
<b>Chapter 5: Hardware Implementation Using FPGA .....</b>	<b>49</b>
5.1 Introduction to VHDL .....	49
5.2 Introduction to FPGA .....	50
5.3 Hardware Implementation of Schnorr-Euchner Sphere decoder .....	52
<b>Chapter 6: Conclusion and future work .....</b>	<b>60</b>
6.1 Conclusion .....	60
6.2 Future Work.....	61
<b>REFERENCES.....</b>	<b>62</b>



# **Study on Spatial Multiplexing Techniques in MIMO Systems**

## **Abstract**

Multiple Input Multiple Output (MIMO) techniques use multiple antennas at both transmitter and receiver for increasing the channel reliability and enhancing the spectral efficiency of wireless communication system. MIMO Spatial Multiplexing (SM) is a promising technology that used to increase the channel capacity without additional spectral resources. The implementation of MIMO detection techniques become a difficult mission as the computational complexity increases with the number of transmitting antenna and constellation size. So designing detection techniques that can recover transmitted signals from Spatial Multiplexing (SM) MIMO with reduced complexity and high performance is challenging. In this thesis, the general model of MIMO communication system is presented in addition to multiple MIMO Spatial Multiplexing (SM) detection techniques, the optimal and sub-optimal MIMO detection schemes have been analyzed. These detection techniques are divided into different categories, such as linear detection techniques like Zero-Forcing that offer low complexity with degraded Bit Error Rate (BER) performance as compared to non-linear techniques like VBLAST, that more complexity than linear but it offers acceptable performance. Tree techniques like Sphere Decoder that provides optimal performance but it suffers from exponential complexity. Detailed discussions on the advantages and disadvantages of each detection algorithm are introduced. In this research, seeking the electronic design of building blocks of communication systems, we will concentrate on Schnorr-Euchner sphere decoder algorithm where the algorithm is designed and implemented in field programmable gate arrays FPGA using VHDL. The Schnorr-Euchner Sphere Decoder algorithm has been generated using an optimized simulator. This simulation has been developed using Modelsim simulator ® platform and implemented using VHDL/FPGA .

## **List of Figures**

Fig.1.1: GSM 2G cellular network architecture.	14
Fig.1.2: 3G system architecture.	15
Fig.1.3: LTE deployment worldwide.	16
Fig.1.4: 4G architecture.	19
Fig.2.1: MIMO System Model.	27
Fig.2.2: Transmit diversity.	28
Fig.2.3: Receive diversity.	29
Fig.2.4: MIMO Spatial Multiplexing System.	29
Fig.3.1: SM Detection techniques.	32
Fig.3.2: Flowchart of Maximum likelihood algorithm.	33
Fig.3.3: Flowchart of SIC algorithm.	37
Fig.3.4: SQRD algorithm and signal detection.	40
Fig.4.1: Geometric representation of the SD algorithm.	42
Fig.4.2: Tree pruning.	44
Fig.4.3: Decoding tree with a Depth-First strategy.	45
Fig.4.4: Decoding tree with a Breadth-First strategy.	45
Fig.4.5: Fincke and Phost Sphere Decoding Algorithm.	46
Fig.4.6: Schnorr-Euchner Sphere Decoding Algorithm.	47
Fig.5.1: FPGA structure.	51
Fig.5.2: Flowchart indicate the steps of signal processing.	53
Fig.5.3. Flowchart of Schnorr- Euchner Sphere decoding algorithm.	54
Fig.5.4: Block diagram of the special adder for 32-bit floating point.	55

Fig.5.5: ModelSim wave diagram for the 32-bit floating point adder/subtraction output.	55
Fig.5.6: Block diagram of the special multiplier for 32-bit floating point.	56
Fig.5.7: ModelSim wave diagram for the 32-bit floating point multiplier output.	56
Fig.5.8: Block diagram of the hardware building blocks of Schnorr-Euchner Sphere decoder.	57
Fig.5.9: ModelSim wave diagram of Schnorr-Euchner Sphere decoder.	58
Fig.5.10: Xilinx area report of Schnorr-Euchner Sphere decoder.	58



## List of Abbreviations

MIMO: Multiple-Input Multiple-Output.

SISO: Single-Input Single-Output.

SNR: Signal to Noise Ratio.

$\Omega$ : Constellation set.

iid : independent and identically distributed.

SM: Spatial Multiplexing.

MLD: Maximum Likelihood Detector.

SD: Sphere Decoding.

ZF: Zero-Forcing.

MMSE: Minimum Mean Square Error.

$()^\dagger$ : Moore-Penrose pseudo-inverse.

VBLAST: Vertical Bell Laboratories Layered Space Time.

SD: Sphere Decoding.

FP: Fincke-Pohst searching strategy.

SE: Schnorr-Euchner searching strategy.