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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

By

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B.Sc degree in Electrical Engineering

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STATEMENT

This thesis is submitted as a partial Fulfillment of Master of Science, In Electrical

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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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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 exponentional 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 .

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List of Abbreviations

MIMO: Multiple-Input Multiple-Output.

SISO: Single-Input Single-Output.

SNR: Signal to Noise Ratio.

Ω: 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.