

استهلال

بسم الله الرحمن الرحيم

قال تعالى: ((قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ
الْحَكِيمُ))

صدق الله العظيم

البقره (32)

DEDICATION

This work dedicated to my mighty god Allah who helps me to accomplish this project

To who guide me from darkness to lightness....

My lover prophet Mohammed

To the greatest person when open my eyes for the first time I saw her

My mother

To who help me to understand the life

My father

To those support me by giving knowledge

My teachers “God help them in their life”

To those stay with me in sadness and happiness....

My friends

To my lovely university....

Sudan University of Science and Technology

To ***everybody*** in my life

ACKNOWLEDGEMENT

First, thank God Almighty which given us the mind, given us the ability to learn and perform difficult tasks, without him this project cannot done.

Then very special thanks to the virtuous supervisor *A.Mayada Abdelgadir*

That gave me a lot of advices and did not skimp on me something that I cannot give her foreordainno matter what I said.

Finally, thanks to all teachers and lecturers in the School of Electronic Engineering, those contributed in learning me until I reached to this stage.

ABSTRACT

Generally, Multiple Inputs Multiple Outputs (MIMO) is a promising technology for future wireless communications systems. By exploiting the multi-dimensional wireless channel created by multiple transmit and receive antennas, MIMO system significantly increase the channel capacity and link robustness of wireless communications. However, MIMO system is difficult to implement in mobile terminal due to the limitations of size and cost. The cooperative relaying system enables single antenna mobiles in a multi-user environment to share their antennas and generate a virtual multiple antenna transmitters. The relay helps the source to communicate with the destination to achieve reliable communication.

This project investigates a single relay system that aims for a reliable communication. The main goal is to study the feasibility of the proposed single relay transmission system in the mobile environment and in addition proposed appropriate coding techniques to improve the reliability in terms of Bit Error Rate (BER).

المستخلص

إستخدام عدد من الهوائيات في عمليه الإرسال والإستقبال يعتبر تقنيه واعدده لأنظمه الإتصال اللاسلكيه . عن طريق هذه التقنيه أمكن إرسال أكثر من نسخه من نفس الإشاره , وبالتالي تأثير القناه على هذه الاشارات يختلف من إشاره لأخرى , لذلك يمكن لهذه التقنيه من زياده مقدار البيانات المرسله في الشبكات اللاسلكيه.ولكن هذه التقنيه من الصعب تطبيقها في أنظمه الموبايل نسبه لأنها تحتاج لمساحه كبيره وتستهلك طاقه كبيره ومكلفه , أما في انظمه الموبايل يتطلب صغر الحجم وتقليل مقدار الطاقه المستهلكه والتكلفه. إستخدام نظام البث التعاوني يتيح لهوائيات أجهزه الموبايل بالإتصال مع بعضها البعض وتكوين نظام متعدد الارسال ومتعدد الإستقبال ,حيث يقوم الباعث بمساعدته المرسل للإتصال مع المستقبل لتحقيق إتصال فعال وموثوق به.

هذا المشروع يقيم أدائيته نظام إتصال يستخدم باعث واحد الهدف منه التأكد من إمكانيه استخدام هذه التقنيه في أنظمه الموبايل بصوره عمليه , وبالإضافه إلى ذلك تم إقتراح تقنيات ترميز مناسبه لتقليل مقدار الخطأ في الإشارات المستقبليه.

TABLE OF CONTENTS

CHAPTR	TITLE	PAGE
	DECLARATION	I
	DEDICATION	II
	ACKNOWLEDGEMENTS	III
	ABSTRACT	IV
	ABSTRACT IN ARABIC	V
	TABLE OF CONTENTS	VI
	LIST OF TABLES	X
	LIST OF FIGURES	XI
	LIST OF ABBREVIATIONS	XIV
	LIST OF SYMBOLS	XVI
1	INTRODUCTION	1
	1.1 Background	2
	1.2 Problem Statement	3
	1.3 Proposed solution	4
	1.4 Research Objective	4
	1.5 Research Methodology	4
	1.6 Research Outlines	5
2	MULTIPLE INPUTS MULTIPLE OUTPUTS (MIMO) SYSTEM	7
	2.1 Introduction	8

2.1.1 Single Input Single Output System(SISO)	9
2.1.2 Single Input Multiple Outputs System (SIMO)	10
2.1.3 Multiple Inputs Single Output System (MISO)	11
2.1.4 Multiple Inputs Multiple Outputs System (MIMO)	12
2.2 System Capacity	14
2.2.1 SISO System Capacity	14
2.2.2 SIMO System Capacity	15
2.2.3 MISO System Capacity	15
2.2.4 MIMO System Capacity	16
2.3 Transmission Techniques	16
2.3.1 Spatial Diversity	17
2.3.2 Spatial Multiplexing	19
2.4 Receiving Combining Techniques	20
2.4.1 Equal Gain Combining (EGC) Technique	20
2.4.2 Fixed Ratio Combining (FRC) Technique	21
2.4.3 Maximum Ratio Combining (MRC) Technique	22
2.4.4 Enhanced Signal to Noise Ration Combining (ESNRC) Technique	23

3	COOPERATIVE RELAYIN TECHNIQUES	24
	3.1 Introduction	25
	3.2 Cooperative Communications Scheme	26
	3.3 Single Relay System	27
	3.4 Single Relay System Protocols	28
	3.4.1 Fixed Amplify and Forward Relaying Protocol	30
	3.4.2 Fixed Decode-and-Forward Relaying Protocol	31
	3.5 Relay Selection	33
	3.6 Different Modulation Techniques	38
	3.6.1 Binary Phase Shift Keying (BPSK)	39
	3.6.2 Quadrature Phase Shift Keying (QPSK)	39
	3.6.3 Orthogonal Frequency Division Multiplexing (OFDM)	41
4	SPACE TIME BLOCK CODING (STBC)	44
	4.1 Introduction	45
	4.2 Space Time Coded (STC) Systems	46
	4.3 Space Time Coding Type	47
	4.3.1 Space Time Block Codes (STBC)	47
	4.3.2 Space Time Trellis Codes (STTC)	48
	4.4 Alamouti Space Time Code	49
	4.5 Advantages and Disadvantages of STBC	53
5	SIMULATION RESULTS	54
	5.1 Introduction	55

	5.2 MIMO System Capacity	56
	5.3 Equidistant Arrangement	57
	5.3.1 Amplify and Forward [AAF]	57
	5.3.2 Decode and Forward [DA F]	59
	5.3.3 Amplify and Forward versus Decode and Forward	60
	5.3.4 Symbol Detection	62
	5.4 Moving the Relay	63
	5.4.1 Relay between Sender and Destination	63
	5.4.2 Equidistant Position of the Relay	64
	5.5 Alamouti Space Time Code	65
6	CONCLUSION AND RECOMMENDATIONS	67
	6.1 Conclusion	68
	6.2 Recommendations	69
	REFERENCES	70
	Appendices A - C	76-91

LIST OF TABLES

TABLE NO	TITLE	PAGE
3-1	Carrier Phase Shift for each Pair of Bits Represented	40
5-1	Simulation Parameters	56

LIST OF FIGURES

FIGUR NO	TITLE	PAGE
2-1	Single Input Single Output (SISO) System	9
2-2	Single Input Multiple Outputs (SIMO) System	10
2-3	Multiple Inputs Single Output (MISO) System	11
2-4	Multiple Inputs Multiple Outputs (MIMO) System	13
2-5	Spatial Diversity Technique	18
2-6	Spatial Multiplexing Technique	19
3-1	Single Relay System	28
3-2	Simplified Cooperation Mode	30
3-3	Amplify and Forward System Model	31
3-4	Decode and Forward System Model	32
3-5	Relay Selection	33
3-6	Multi-node Relay selection Cooperative Communication System	35
3-7	Binary Phase Shift Keying	39
3-8	Modulation as Phasor Diagram and Constellation Diagram	41
3-9	The OFDM Orthogonal Set of Modulation Signals in the Frequency Domain	42

3-10	Schematic of a MIMO-OFDM system	43
4-1	block diagram of the Alamouti space time encoder	49
4-2	Alamouti's Two Antennas Transmit Diversity Scheme	51
5-1	Single Relay Simulated Model	56
5-2	SISO, MISO, MIMO systems capacity versus SNR	57
5-3	Different Combining Method Using AAF	58
5-4	Different Combining Method Using DAF	60
5-5	Comparison between AAF and DAF with	61
5-6	Different Combining Methods AAF versus DAF using Different Combining Methods with Symbol Detection	62
5-7	Different Relay Locations between the Sender and the Destination	64
5-8	Different Relay Locations between the Sender and the Destination	65
5-9	Alamouti's Effect in the Transmission System	66

LIST OF ABBREVIATIONS

SISO	Single Input Single Output
SIMO	Single Input Multiple Outputs
MISO	Multiple Inputs Single Output
MIMO	Multiple Inputs Multiple Outputs
MRC	Maximal Ratio Combining
EGC	Equal Gain Combining
SNRC	Signal to Noise Ratio Combining
FRC	Fixed Ratio Combining
ESNRC	Enhanced Signal to Noise Ratio Combining
AAF	Amplify and Forward
DAF	Decode and Forward
BPSK	Binary Phase Shift Keying
QPSK	Quadrature Phase Shift Keying
OFDM	Orthogonal Frequency Division Multiplexing
4G	Four Generation
ISI	Inter Symbol Interference
CP	cyclic prefix
FFT	Fast Fourier Transform
IFFT	Inverse Fast Fourier Transform
BER	Bit Error Rate
SNR	Signal to Noise Ratio
STBC	Space Time Block Coding

STC	Space Time Coding
ML	Maximum Likelihood
OSTBC	Orthogonal Space Time Block Coding
SP	Serial to Parallel
STTC	Space Time Trellis Codes

LIST OF SYMBOLS

S	Source
R	Relay
D	Destination
Y	Received Signal
X	Transmitted Signal
n	Complex Gaussian Noise
H	Normalized Channel Matrix
C	Capacity of the System
B	Bandwidth
SNR	Signal to Noise Ratio
n	Number of Receiving Antennas
m	Number of Transmitting Antennas
y	Total Received Signals
y_{i,d}	Incoming Signal from Path Number i
k	Number of Different Paths
y_{s,d}	Received Signal from the Source
y_{r,d}	Received Signal from the Relay
d_{i,d}	Weighting of the Incoming Signal $y_{i,d}$
d_{s,d}	Weight of the Direct Link
d_{s,r,d}	Weight of the Multi-hop Link
h_{s,d}[*]	complex conjugate of channel for Source signal

$\mathbf{h}_{r,d}^*$	Complex Conjugate of Channel for relay Signal
$\mathbf{y}_{s,r,d}$	Received Signal from the Source to the Relay to the Destination
$\mathbf{SNR}_{s,d}$	Signal to Noise Ratio of the Signal from the Source to the Destination
$\mathbf{SNR}_{s,r,d}$	Signal to Noise Ratio of the Signal from the Source to the Relay to the Destination
$\mathbf{y}_{s,r}$	Received Signal in the Relay
$\mathbf{h}_{s,d}$	Channel Coefficient from Source to the Destination
$\mathbf{h}_{s,r}$	Channel Coefficient from Source to the Relay
$\mathbf{n}_{s,d}$	Additive Noise Source to the Destination
$\mathbf{n}_{s,r}$	Additive Noise from Source to the Relay
$\mathbf{P}$	Transmitted Power at the Source
$\mathbf{x}$	Transmitted Information Symbol
$\mathbf{h}_{r,d}$	Channel Coefficient from Relay to the Destination
$\mathbf{n}_{r,d}$	Additive Noise Relay to the Destination
$\mathbf{q}$	Function depend on which Processing is implemented at the Relay Node
$\mathbf{p}_2$	Transmitted Power in the Second Phase
$\mathbf{s}_1$	The information sequence from the first antenna
$\mathbf{s}_2$	The information sequence from the second antenna
$\mathbf{h}_i$	The amplitude gain
θ_i	Phase shift for the path from transmit antenna i to the receive antenna
$\mathbf{t} + \mathbf{T}$	The time of the received signals
$\mathbf{r}_1$	The received signals at time t

$\mathbf{r}_2$	The received signals at time $t + T$
$\mathbf{n}_1, \mathbf{n}_2$	Complex random variables representing receiver noise and interference
$\mathbf{r}$	The received signals
$\mathbf{S}$	Code matrix
$\mathbf{H}$	The complex channel vector
$\mathbf{n}$	The noise vector