

# Dedication

*This work is dedicated with great thanks to  
my parents, my brothers and sister ...*

*To my relatives ...*

*To everyone taught me a letter ...*

*To my friends and colleagues ...*

*And I thank all my professor at the Sudan  
University and Al Jazeera University*

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,,, Many thanks to all,,,

# ABSTRACT

The next generation of wireless communications high data rate and link with high reliability became main factors in measuring the performance of system. Therefore massive Multiple Input Multiple Output systems (massive MIMO) will be promising technology for fifth generation wireless communication to cover the increasing number of users and various wireless applications with acceptable data rate and link with high reliability. Multi User Interference (MUI) is main problem in performance of massive MIMO system. This thesis focus on Multi User Interference(MUI), which is interference results from other user in same cell which has one of the major impact factor in decreasing performance (achievable data rate) of cellular communication system when more users access to the wireless link. The specific goal is to eliminate or mitigate the effect of multi user interference to enhance system performance by increasing number of base station antennas and applying linear pre-coding techniques. This research presents the study and compare the performance analysis of two linear pre-coding techniques which are Matched Filter (MF) and Zero Forcing (ZF) for downlink massive multiple input multiple output System over perfect channel depending on vector normalization and matrix normalization methods when number of base station antennas from 1 to 300 and from 1 to 600, number of user from 1 to 200 and downlink transmitting power 0 dB and -10 dB. Simulations results show that using linear pre-coding techniques and increasing number of base station antennas enhance system performance. When number of base station antenna 600 the achievable sum rate improvements for ZF and MF (433.7451 bit/sec/Hz, 433.2624 bit/sec/Hz ) at high power and ( 86.5119 bit/sec/Hz 86.3519 bit/sec/Hz ) at low power respectively. The results indicate that vector normalization and matrix normalization for ZF gives better performances at high downlink transmission power (0 dB) while at low power MF has better performance in vector normalization and ZF has better performance in matrix .

## المستخلص

للجيل القادم من الاتصالات اللاسلكية معدل البيانات العالي وقناة ذات موثوقية عالية أصبحا عاملين رئيسيين في قياس أداء النظام. وبالتالي نظام متعددة الإدخال متعددة المخرجات الهائلة سوف يكون تكنولوجيا واعدة للجيل الخامس للاتصالات اللاسلكية لتغطية العدد المتزايد للمستخدمين و التطبيقات اللاسلكية المتعددة بمعدل بيانات مقبول و موثوقية عالية. التداخل متعدد المستخدمين من المشاكل الرئيسية في أداء نظام متعددة الإدخال متعددة المخرجات الهائلة. وهذه الرسالة تركز على التداخل متعدد المستخدمين والذي هو التداخل الناتج من مستخدم آخر في نفس الخلية والذي لديه عامل تأثير كبير في خفض الأداء (معدل البيانات المتوقع) في نظام الاتصالات الخلوية عند وصول المزيد من المستخدمين إلى قناة لاسلكية. الهدف المحدد هو إزالة أو تخفيف تأثير التداخل متعدد المستخدمين لتحسين أداء النظام عن طريق زيادة عدد هوائيات المحطة الأساسية وتطبيق تقنيات الترميز المبدئي الخطي. هذا البحث يقدم دراسة ومقارنة تحليل الأداء لاثنتين من تقنيات الترميز المبدئي الخطي والتي هي الفلتر المطابق والتصغير القسري للوصلة الهابطة لنظام متعددة الإدخال متعددة المخرجات الهائلة عبر قناة مثالية اعتمادا على طريقتي توحيد المتجه وتوحيد المصفوفة عند تكون هوائيات المحطة الأساسية من 1 إلى 300 ومن 1 إلى 600 وعدد المستخدمين من 1 إلى 200 عند قدرة الوصلة الهابطة 0dB و -10dB. أظهرت نتائج المحاكاة أن استخدام تقنيتي الترميز المبدئي الخطي وزيادة عدد هوائيات المحطة الأساسية تحسن أداء النظام. وعندما كانت عدد الهوائيات في المحطة الأساسية 600 كان التحسين في معدل البيانات المتوقع لتقنية التصغير القسري والفلتر المطابق ( 433.7451 بت/ث/هيرتز و 433.2624 بت/ث/هيرتز عند الطاقة العالية و 86.5119 بت/ث/هيرتز و 86.3519 بت/ث/هيرتز عند الطاقة المنخفضة على التوالي . وتشير النتائج إلى أن توحيد المتجه وتوحيد المصفوفة للتصغير القسري تعطي أفضل أداء عندما تكون قدرة الوصلة الهابطة عالية (0dB) بينما في القوة المنخفضة فلتر المطابقة لديه أداء أفضل في توحيد المتجه والتصغير القسري لديه أداء أفضل في توحيد المصفوفة.

# Table of Contents

	Dedication	I
	Acknowledgments	II
	Abstracts	III
	المستخلص	IV
	Table of contents	V
	List of figure	VII
	List of table	VIII
	List of abbreviations	IX
	List of sample	X
	<b>Chapter 1: Introduction</b>	
1.1	Preface	1
1.2	Problem statement	2
1.3	Propose solution	2
1.4	Aim and Objective	2
1.5	Scope of work	2
1.6	Methodology	3
1.7	Thesis outlines	3
	<b>Chapter 2: Literature review</b>	
2.1	Overview	4
2.2	Background	4
2.2.1	Advantage of MIMO Technology	5
2.2.2	MIMO Channel Systems Model	7
2.3	Relate works	14
2.3.1	Pre-coding Techniques	16
	<b>Chapter 3: System Model</b>	
3.1	Mathematical model	25
3.2	Linear Pre-coding Techniques	27
3.2.1	Zero Forcing Pre-coding (ZF) Technique	27
3.2.2	Matched Filter Pre-coding (MF) Technique	27
3.3	Normalization Method	27
3.3.1	ZF and MF with Vector Normalization	28
3.3.2	ZF and MF with Matrix Normalization	28
3.4	Achievable Sum Rate	28
3.4.1	Achievable Sum Rate for Zero Forcing (ZF) Pre-coding	29
3.4.2	Achievable Sum Rate for Matched Filter (MF) Pre-coding	29
	<b>Chapter 4 : Results and Discussion</b>	
4.1	Vector Normalization	32
4.1.1	Performance of MF and ZF Using Vector Normalization at $K=50,100,150$ and 200 Users	33
4.1.2	Performance of MF and ZF Using Vector Normalization at $M=300, 400 ,$ 500 and 600 Antennas	35
4.2	Matrix Normalization	38

4.2.1	Performance of MF and ZF Using Matrix Normalization at $K= 50 , 100 , 150$ and $200$ Users	38
4.2.2	Performance of MF and ZF Using Matrix Normalization at $M=300 , 400 , 500 , 600$ Antennas	40
4.3	Vector Normalization Versus Matrix Normalization	44
4.3.1	Vector Normalization Versus Matrix Normalization at $600$ Antennas and $0\text{dB}$	44
4.3.2	Vector Normalization Versus Matrix Normalization at $600$ Antennas and $-10\text{dB}$	44
<b>Chapter 5 : Conclusion and Recommendation</b>		
5.1	Conclusion	46
5.2	Recommendation	47
<b>References</b>		
<b>Appendixes</b>		
	Appendix A	53
	Appendix B	54
	Appendix C	55
	Appendix D	56
	Appendix E	57

## List OF Figures

2.1	SISO system	7
2.2	SIMO system	8
2.3	MISO system	9
2.4	MIMO system	10
2.5	SU- MIMO system	11
2.6	MU- MIMO system	11
2.7	Massive MIMO system model	13
2.8	Single-cell broadcast	15
2.9	Relation between linear and non-linear pre-coding techniques	18
2.10	Network MIMO for cellular communications	19
2.11	Massive MIMO for cellular communications	20
3.1	A single-cell downlink massive MIMO system	25
3.2	A downlink massive MIMO system model	26
3.3	Flow chart of fixed number of antennas with different number of users	30
3.4	Flow chart of different number of antennas with fixed number of users	31
4.1	Performance of MF and ZF using vector normalization [at $k=50$ & $M=1:600$ ]	33
4.2	Performance of MF and ZF using vector normalization [at $k=100$ & $M=1:600$ ]	34
4.3	Performance of MF and ZF using vector normalization [at $k=150$ & $M=1:600$ ]	35
4.4	Performance of MF and ZF using vector normalization [at $k=200$ & $M=1:600$ ]	36
4.5	Performance of MF and ZF using vector normalization [at $M=300$ & $k=1:200$ ]	36
4.6	Performance of MF and ZF using vector normalization [at $M=400$ & $k=1:200$ ]	36
4.7	Performance of MF and ZF using vector normalization [at $M=500$ & $k=1:200$ ]	37
4.8	Performance of MF and ZF using vector normalization [at $M=600$ & $k=1:200$ ]	38
4.9	Performance of MF and ZF using matrix normalization [at $k=50$ & $M=1:600$ ]	39
4.10	Performance of MF and ZF using matrix normalization [at $k=100$ & $M=1:600$ ]	40
4.11	Performance of MF and ZF using matrix normalization [at $k=150$ & $M=1:600$ ]	40
4.12	Performance of MF and ZF using matrix normalization [at $k=200$ & $M=1:600$ ]	41
4.13	Performance of MF and ZF using matrix normalization [at $k=1:200$ & $M=300$ ]	42
4.14	Performance of MF and ZF using matrix normalization [at $k=1:200$ & $M=400$ ]	42
4.15	Performance of MF and ZF using matrix normalization [at $k=1:200$ & $M=500$ ]	43
4.16	Performance of MF and ZF using matrix normalization [at $k=1:200$ & $M=600$ ]	43
4.17	Matrix normalization vs. Vector normalization [at $k=200$ , $M=1:600$ & $\text{Pad}=0\text{dB}$ ]	44
4.18	Matrix normalization vs. Vector normalization [at $k=200$ , $M=1:600$ & $\text{Pad}=-10\text{dB}$ ]	45

## List OF Tables

2.1	Illustrates of various antennas types	10
4.1	Simulation parameters for Vector normalization	32
4.2	Simulation parameters for Matrix normalization	38
4.3	Sum rate improvements for MF and ZF at M=600antennas & K=50, 100, 150 and 200 .	45
4.4	Sum rate improvements for MF and ZF at M=300antennas & K=50, 100, 150 and 200 .	46



## List of Abbreviations

4G	Fourth Generations
5G	Fifth Generations
BD	Block Diagonalization
BS	Base Station
CMA	Constant Modulus
CSI	Channel State Information
ESPARs	Electronically steerable passive array radiators
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
GSM	Global System for Mobile
LTE	Long Term Evolution
MAC	Media Access Control
MF	Matched Filter
MIMO	Multiple Input Multiple Output
MISO	Multiple Input Single Output
ML	Maximum Likelihood
MMSE	Minimum Mean Square Error
RF	Radio Frequency
RRHs	Remote Radio Heads
MRT	Maximum Ratio Transmission
MSINR	Maximum Signal to Interference and Noise Ratio
MSNR	Maximum Signal to Noise Ratio
MTs	Mobile Terminals
MUI	Multi User Interference
MU-MIMO	Multi User- Multiple Input Multiple Output
SD	Spatial Diversity
SDMA	Space Division Multiple Access
SIMO	Single Input Multiple Output
SISO	Single Input Single Output
SM	Spatial Multiplicity
SNR	Signal to Noise Ratio
SU-MIMO	Single User- Multiple Input Multiple Output
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
ZF	Zero Forcing

## List Of Symbols

$M$	Number of Antennas
$H$	Channel Matrix
$h_k^T$	Channel Vector
$y_k$	Received Signal
$R$	Channel Capacity
$R_k$	Achievable sum rate per user
$R_{MF_{vec}}$	The achievable sum rate for matched filter by using vector normalization
$R_{MF_{mat}}$	The achievable sum rate for matched filter by using matrix normalization
$R_{ZF_{vec}}$	The achievable sum rate for zero forcing by using vector normalization
$R_{ZF_{mat}}$	The achievable sum rate for zero forcing by using matrix normalization
$R_{sum}^{MF}$	A achievable sum rate with Matched Filter
$R_{sum}^{ZF}$	Achievable sum rate with Zero Forcing
$R_{sum}$	Achievable sum rate
$K$	Number of Users
$P_d$	Transmit power in a downlink
$n_k$	White Gaussian noise vector
$W$	Pre-coding matrix
$w_k$	Column vector of transmit and receive
SNR	Signal to noise ratio
$S_k$	Transmit symbol
$H^*$	Conjugate transpose of channel matrix