

ACKNOWLEDGEMENT

I am very grateful to Allah, for giving me the strength and courage me to complete my MSC study at Sudan University of Science and Technology (SUST), despite all the difficulties that I have been through. I would like to thanks my parents and my brothers, all my relatives. I would like to acknowledge and extend my heartfelt gratitude, to my thesis supervisor **Dr. Mohamed Hussain Mohamed** at SUST, for his supporting and encouragement which has made the completion of this thesis possible. Throughout my work with this thesis, Thanks for catching my misunderstandings and unclear wordings and thereby greatly improving the quality of this report. Thanks also for all his ideas and suggestions; they have guided me to improve my technical and non-technical skills as well. Special thanks to everyone give support through this work. I must express appreciation and sincere gratitude to those individuals who have been helpful to me during the preparation of this work. My greatest appreciation also goes, to **Nyala University** for continuous supporting me to complete the MSC program.

I would like to thank my all friends and doctors individually in MSC-Telecommunication Batch 7, with especially thanks to **Miss. Nidaa Elsheikh**.

ABSTRACT

Long Term Evolution (LTE) has been investigated, because of high data rate, low latency and packet optimized radio access technology. While orthogonal frequency division multiple accesses (OFDMA) is used in multiplexing, the main drawback of OFDMA is high peak to average power ratio (PAPR) properties of an OFDMA signal, resulting in worse uplink coverage. Thus SC-FDMA (Single Carrier Frequency Division Multiple Access) is suggested using LTE uplink, which presents better PAPR properties compared to OFDMA signal. But In uplink transmission, the user equipment (UE) causes the interference to other neighbor cell, this degrades the cell performance, therefore close loop power control (CLPC) and open loop power control (OLPC) are suggested and modeled to solve this problem. In the OLPC, the signal strength UE which reach to neighbor cell is considered to set transmit power. In CLPC the adjustment of power control (PC) command continuously and then set transmit power. The main contribution of this research focuses on the affect of OLPC and CLPC in the bit error rate (BER). The simulation is achieved using MATLAB and the results showed that, at signal to noise ratio (SNR) 25dB, the OLPC and CLPC given typical BER of (10^{-5}) . In term of the power, the OLPC consumes much power as compared to CLPC. Compared when the SNR less than 10dB, the OLPC achieves better results as compared to CLPC; otherwise the CLPC gives better results.

التجريد

تم تطوير التطور الطويل الامد نسبة لامتياز به معدل البيانات العالية والتاخير الاقل. في هذه التقنية استخدم الوصول المتعدد بتقسيم التردد المتعامدة، ولكن المشكلة الاساسية في هذه التقنية ان نسبة القدرة القصوى للمتوسطة فيها عالية جدا، وهذه تؤدي الى ضعف التغطية في الوصلة الصاعدة لذا تم اقتراح الوصول المتعدد بتقسيم التردد ذات الحامل المفرد للوصلة الصاعدة، والتي تمثل نسبة القدرة القصوى للمتوسطة فيها جيدة مقارنة مع اشارة تقنية الوصول المتعدد بتقسيم التردد المتعامدة. ولكن الارسل عن طريق الوصلة الصاعدة من مستخدم الموبايل الى المحطة الاساسية يسبب تداخل الى الخلية الجارة، وهذه تؤثر على اداء الخلية، لذا اقترح التحكم في قدرة الارسل بواسطة الحلقة المفتوحة والتحكم في قدرة الارسل بواسطة الحلقة المغلقة لحل هذه المشكلة. في حالة الحلقة المفتوحة اعتبر قوة الاشارة من المستخدم الى الخلية الجارة لضبط قدرة الارسل وفي حالة الحلقة المغلقة تم الضبط المستمر لامر تحكم القدرة لضبط قدرة الارسل. الاضافة الفعلية لهذا البحث ركز على تاثير الحلقة المفتوحة والحلقة المغلقة على معدل الخطأ في البيانات. المحاكاة تمت بواسطة الماتلاب والنتائج وضحت ان: في حالة نسبة الاشارة للضجيج تساوي 25 ديسبل واعلى، فان الحلقة المغلقة والحلقة المفتوحة تعطيان نفس قيمة معدل الخطأ في البيانات (10^{-5}). بالنسبة للقدرة فان الحلقة المفتوحة تستهلك قدرة اكثر مقارنة مع الحلقة المغلقة. عند نسبة الاشارة للضجيج اقل من او تساوي 10 ديسبل الحلقة المفتوحة اعطت نتائج افضل من الحلقة المغلقة، وعند اي قيمة اخرى لنسبة الاشارة للضجيج الحلقة المغلقة افضل.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	Acknowledgement	i
	Abstract	ii
	التجريد	iii
	List of figures	viii
	Abbreviations	ix
	Notations	xii
Chapter One:	Introduction	1
1.1	Preface	1
1.2	Problem Statement	2
1.3	Objective	2
1.4	Scope of Thesis	3
1.5	Thesis Outline	3
Chapter Two:	Overview of LTE and Power Control	5
2.1	Radio Channel and Propagation	5
2.1.1	Signal Propagation	6
2.1.2	Path Loss	7
2.1.3	Shadow and Fading	8
2.1.4	Multipath Fading	8
2.2	3GPP Long Term Evolution	10
2.2.1	LTE Performance Demands	11
2.2.2	LTE Uplink and Downlink Duplex	13
2.2.3	Uplink Transmission	14

2.2.4	LTE Physical Layer	16
2.2.5	Orthogonal Frequency Division Multiplexing	16
2.2.6	Orthogonal Frequency Division Multiple Access	17
2.2.7	Single Carrier Frequency Division Multiple Access	19
2.2.8	OFDM to SC-FDMA	20
2.2.9	LTE Radio Access	20
2.3	Multiple Input Multiple Output	21
2.3.1	Overview of MIMO Technique	21
2.3.2	MIMO Definition	22
2.3.3	MIMO System Capacity	23
2.4	Power Control	26
2.4.1	Power Control Concept in LTE	26
2.4.2	Open Loop Power Control	27
2.4.3	Close Loop Power Control	28
2.5	Aim of Power Control	29
2.5.1	Related Works	31
2.5.2	LTE PUSCH Power Control	32
2.5.3	PUSCH Power Control Signaling	33
2.5.4	Power Spectral Density	33
Chapter Three:	System Design and Modeling	35
3.1	Introduction	35
3.2	Methodology	35
3.3.1	Interference Scenario	36

3.3.2	Simulation Assumption and Parameters	37
3.3.3	The Power Control Schemes	38
3.3.3.1	Open Loop PC Scheme	39
3.3.3.2	Close Loop PC Scheme	40
Chapter Four:	Results and Discussions	44
4.1	Introduction	44
4.2	Path Loss Analysis	44
4.3	Bit Error Rate Analysis	46
4.4	Throughput Analysis	55
Chapter Five:	Conclusion and Future Work	61
5.1	Conclusion	61
5.2	Future Work	62
Publications		63
References		64

LIST OF FIGURES

FIGURE	TITLE	PAGE
Fig2.1	Multipath Propagation Models	7
Fig2.2	Direct, Reflected and Diffracted Signals Outside Building	10
Fig2.3	Reflected, Diffracted and Scattered Signals Inside Building	12
Fig2.4	Scattering, Reflected, Diffracted Signals Outside Building	12
Fig2.5	LTE Frame Structure	14
Fig2.6	Downlink and Uplink Sub Frame Assignment for FDD	16
Fig2.7	Downlink and Uplink Sub Frame Assignment for TDD	16
Fig2.8	Resource Block Structures	18
Fig2.9	OFDM Transmitter and Receiver	20
Fig2.10	Comparisons between Conventional FDM and OFDM	21
Fig2.11	SC-FDMA Transmitter and Receiver	22
Fig2.12	MIMO Systems Concept	26
Fig2.13	MIMO System Structures	28
Fig2.14	MIMO Eigenmode Transmission	28
Fig2.15	Open Loop Power Control	31
Fig2.16	Close Loop Power Control	32
Fig2.17	Uplink Interference Scenario for Femto and Macro Cell	34
Fig2.18	Broadcast Parameters	35
Fig3.1	Uplink Path Loss and Interference Scenario	39
Fig3.2	Open Loop Power Control Flow Chart	44
Fig3.3	Close Loop Power Control Flow Chart	47
Fig4.1	Path Losses and Distance (1 km to 4 km)	48

Fig4.2	Path Losses and Distance (4 km to 5 km)	49
Fig4.3	Path Losses and Distance (400 m to 5 km)	50
Fig4.4	BER versus SINR (PC Period 110ms and Iterations 1000)	51
Fig4.5	BER versus SINR (PC Period 110ms and Iteration 2000)	52
Fig4.6	BER versus SINR (PC Period 110ms and Iterations 5000)	53
Fig4.7	BER versus SINR (PC Period 200ms and Iterations 1000)	54
Fig4.8	BER versus SINR (PC Period 90 ms, Iteration is 1000)	55
Fig4.9	BER versus SINR (Period 80 ms Iteration 1000)	56
Fig4.10	BER versus SINR (Period 50 ms Iteration 1000)	57
Fig4.11	BER versus SINR (Period 20 ms Iteration 1000)	58
Fig4.12	Throughput versus Power: Distance (1km to 4km)	59
Fig4.13	Throughput versus Power: Distance (400m to 5km)	60
Fig4.14	Throughput versus Power (Iteration 9000)	61
Fig4.15	Throughput versus Power (Iteration 10000)	62
Fig4.16	Throughput versus SINR (Distance 400 m)	63
Fig4.17	Throughput versus SINR (Distance 1km)	64

ABBREVIATIONS

Abbreviation	Description
3GPP	3 rd Generation Partnership Project
BER	Bit Error Rate
BS	Base Station
BPSK	Binary Phase Shift Keying
CQI	Channel Quality Indicator
CLPC	Close Loop Power Control
CP	Cyclic Prefix
CSI	Channel State Information
CIR	Carrier to Interference Ratio
DL	Downlink
DFTS	Discrete Fourier Transform System
DAC	Digital to Analog Conversion
E-Node-B	Enhanced Base Station
FBS	Femto Base Station
FD-SS	Frequency Domain Stochastic Scheduler
FPC	Fractional Power Control
FDMA	Frequency Division Multiple Access
FDD	Frequency Division Duplex
FDM	Frequency Division Multiplexing
FFT	Fast Fourier Transform
GSM	Global System for Mobile

ICI	Inter Carrier Interference
ISI	Inter Symbol Interference
IFFT	Inverse Fast Fourier Transform
LOS	Line of Sight
LTE	Long Term Evolution
MCS	Modulation and Coding Scheme
MIMO	Multiple Input Multiple Output
MCM	Multicarrier Modulation
MS	Mobile Station
MISO	Multiple Input Single Output
NRB	Number of Resource Block
OFDMA	Orthogonal Frequency Division Multiple Access
OLPC	Open Loop Power Control
OFDM	Orthogonal Frequency Division Multiplexing
PC	Power Control
PDSCH	Physical Downlink Shared Channel
PMCH	Physical Multicast Channel
PBCH	Physical Broadcast Channel
PUSCH	Physical Uplink Shared Channel
PL	Path Loss
PSD	Power Spectral Density
QPSK	Quadrature Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RSRP	Reference Symbol Received Power
RRM	Radio Resource Management

RB	Resource Block
RF	Radio Frequency
SC-FDMA	Single Carrier Frequency Division Multiple Access
SISO	Single Input Single Output
SNR	Signal to Noise Ratio
SIMO	Single Input Multiple Output
SINR	Signal to Interference Noise Ratio
UE	User Equipment
UL	Uplink
UMTS	Universal mobile Telecommunication System
TDD	Time Division Duplex
TTI	Transmit Time Interval
TPC	Transmit Power Control
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network

NOTATIONS

P_{TX}	Transmitted Signal Power
P_{RX}	Received Signal Power
L	Loss
g	Gain
PL	Path Loss
β	Constant depend on antenna specific parameter
γ	Constant Parameter
R	Distance between transmitter and receiver
σ^2	Variance
λ_k^2	Channel gain
q_{kk}	Transmit power for each channel
E_S/N_o	Signal power to noise power
σ_{MSE}^2	Channel estimation error
P_e	Average signal to noise ratio
P_{max}	Maximum transmit power
M	Number of PRBs
α	Cell specific parameters
P_o	Power allocated to one PRB
δ_{msc}	Offset specific to user equipment
$f(\Delta_i)$	The Correction function specific to user
β_o	Positive small value to make system fast

α	The compensation factor
δ	Correction factor
BW_{eff}	Bandwidth efficiency
S_{eff}	SNR efficiency at system level
$PL_{\text{UL},i}$	Uplink Path loss