

الآيـة

وَقُلْ (بِّزِدْنِي عِلْمًا)

سورة طه الآية 114

# **Dedication**

To soul of my father ...

To my mother ...

To soul of my sister Alla ...

To my sisters Esraa and Shaimaa ...

# Acknowledgment

All thanks to Allah who helps me to accomplish this work by giving me the ability and sending up to me great people to aid me.

I would like to thank all my teachers for their support and guidance, especially my teachers **Mr. Yassir Mohammed Obied**, **Mr. Hashim Batran** and especial thank and gratitude for my great supervisor who encourage me all the time **Dr. Mohammed Hussein**.

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# Abstract

One of the essential goal of Long Term Evolution (LTE) is increasing speed and capacity without consuming high power especially in uplink, in order to save battery life of user equipment as long as possible. Since Single Carrier Frequency Division Multiple Access (SC-FDMA) achieves this, it has been utilized in the uplink of 3GPP LTE. However the high capacity and speed will affect the received data since it will cause increasing in Doppler shift. This leads to the need of using channel estimation technique in the receiver (eNodeB) to recover the received signal.

In this thesis SC-FDMA is modeled using MATLAB and then Least Mean Square (LMS) and Variable Step Size Least Mean Square (VSS-LMS) channel estimation techniques are applied in order to evaluate their performance in terms of Bit Error Rate (BER), Mean Square Error (MSE) and algorithm complexity. The evaluation of the algorithms was done under different modulation techniques (Binary Phase Shift Keying (BPSK) and Quaternary Phase Shift Keying (QPSK)) and different channel models (Additive White Gaussian Noise (AWGN) and Rayleigh fading channel with fading shift 5, 50 and 500 Hz).

The simulation results shown that the modulation type affects the performance on BER and MSE; however, channel environment has an obvious effect. VSS-LMS algorithm has better performance than LMS in all cases; however it requires more multiplication and addition operations.

## المستخلص

واحد من الاهداف الجوهرية في التطور بعيد الامد هو زيادة السعة والسرعة في شبكات البيانات اللاسلكية دون الحاجة إلى استهلاك طاقة عالية خصوصا في الارسال من الهاتف النقال إلى محطة الارسال والاستقبال الأساسية وذلك للحفاظ على بطارية الهاتف النقال لاطول فترة ممكنة. بما أن الوصول المتعدد بتقسيم التردد ذات الحامل المفرد يحقق هذا الهدف، تم استخدامه من قبل مشروع شراكة الجيل الثالث للتطور بعيد الامد في الإرسال من الهاتف النقال إلى محطة الارسال والاستقبال الأساسية. لكن السرعة والسعة العالية في التطور بعيد الامد أدى إلى زيادة نسبة الخطأ في البيانات بسبب تأثير القناة بظاهرة دوببلر. ومن هنا دعت الحاجة لاستخدام تقنية لاستنتاج استجابة القناة في محطة الارسال والاستقبال الأساسية.

في هذه الاطروحة تمت نمذجة الوصول المتعدد بتقسيم التردد ذات الحامل المفرد باستخدام برنامج ماتلاب ثم طبقت خوارزميتي مربع المتوسط الاصغر و مربع المتوسط الاصغر ذو الخطوة المتغيرة الحجم على النظام لاستنتاج استجابة القناة وتم تقييم اداءهما بحساب معدل الخطأ في نقل البيانات و متوسط مربع الخطأ بالإضافة إلى تعقيد الخوارزمية. تم تقييم الاداء لعدة حالات مختلفة و ذلك باستخدام نوعين من التعديل (تعديل الطور المفتاحي الثنائي وتعديل الطور المفتاحي الرباعي) وثلاث نماذج للقناة (ضجيج قاوس الأبيض وقناة ريليه ذات التخميد بتردد 5 و 50 و 500 هيرتز).

أظهرت النتائج ان نوع التعديل يؤثر على معدل الخطأ في نقل البيانات و متوسط مربع الخطأ ولكن بيئه القناة لها تأثير اوضح على اداء الخوارزميتين. خوارزمية مربع المتوسط الاصغر ذو الخطوة المتغيرة الحجم تمتاز باداء افضل من خوارزمية مربع المتوسط الاصغر في كل الحالات ولكنها تحتاج إلى عمليات جمع وضرب اكثر من خوارزمية مربع المتوسط الاصغر ذو الخطوة المتغيرة الحجم.

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# List of Symbols

<b>Symbol</b>	<b>Description</b>
$y(n)$	received signal
$h(t)$	channel coefficient
$h_{TS}(n-tT)$	delayed version of transmitted signal
$s(n)$	transmitted signal
$Z(n)$	additive white Gaussian noise
$\tau_{rms}$	root mean square delay spread
$\Delta f$	frequency band
$B$	signal bandwidth
$T_C$	coherence time
$v_{rms}$	root mean square vale of Doppler spread
$\eta$	LMS step size
$\eta_0$	VSS-LMS initial step size
$\eta_{max}$	VSS-LMS maximum step size
$\eta_{min}$	VSS-LMS minimum step size
$\alpha$	positive control parameter
$\beta$	positive control parameter
$\gamma$	positive control parameter
$W(m)$	channel coefficients at time $m$
$W_{est}(m)$	estimated channel coefficients at time $m$
$e(m)$	estimated error

# Abbreviations

<b>Abbreviation</b>	<b>Description</b>
1D	One Dimension
2D	Two Dimension
2G	Second Generation
3G	Third Generation
3GPP	3 <sup>rd</sup> Generation Partnership Project
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BS	Base Station
CE	Channel Estimation
CLPC	Closed LoopPower Control
CP	Cyclic Prefix
DFDMA	DistributedSC-FDMA
DFE	Decision Feedback Equalization
DFT	Discrete Fourier Transform
DSP	Digital Signal Processing
EPA	Extended Pedestrian-A
ETU	Extended Typical Urban
E-UTRA	Evolved UMTS Terrestrial Radio Access
EVA	Extended Vehicular-A
FDD	Frequency Division Duplexing

FFT	Fast Fourier Transform
FIR	Finite Impulse Response
GSM	Global System for Mobile
HSPA	High Speed Packet Access
IBI	Inter Block Interference
ICI	Inter Carrier Interference
IDFT	Inverse Discrete Fourier Transform
IFDMA	InterleavedSC-FDMA
IFFT	Inverse Fast Fourier transform
IMT-2000	International Mobile Telecommunications-2000
ITU	International Telecommunication Union
LFDMA	Localized SC-FDMA
LMMSE	Least Minimum Mean Square Estimation
LMS	Least Mean Square
LOS	Line of Sight
LS	Least Square
LTE	Long Term Evolution
MATLAB	Matrix Laboratory
MMSE	Minimum Mean SquaredError Estimation
MSE	Minimum Square Error
NLMS	Normalized Least Mean Square
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OLPC	Open Loop Power Control
PAPR	Peak to Average Power Ratio

PDP	Power Delay Profile
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quaternary Phase Shift Keying
RF	Radio Frequency
RLS	Recursive Least Square
rms	Root Mean Square
RRM	Radio Resource Management
SC/FDE	Single Carrier Systems with Frequency Domain Equalization
SC-FDMA	Single Carrier Frequency Division Multiple Access
SISO	Single Input Single Output
SNR	Signal to Noise Ratio
TDD	Time Division Duplexing
TTI	Transmit Time Interval
UE	User Equipment
UMTS	Universal Mobile Telecommunication System
VSS-LMS	Variable Step Size Least Mean Square