

الآية

وَقُلْ (رَبُّ زِدْنِي 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 الحوجة الى استهلاك طاقة عالية خصوصا في الارسال من الهاتف النقال الى محطة الارسال والاستقبال الاساسية 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 الى محطة الارسال والاستقبال الاساسية. لكن السرعة والسعة العالية في التطور بعيد الامد أدت الى زيادة نسبة الخطأ في البيانات بسبب تأثر القناة بظاهرة دوبلر. ومن هنا دعت الحوجة لاستخدام تقنية لاستنتاج استجابة القناة في محطة الارسال والاستقبال الاساسية.

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 ومتوسط مربع الخطأ بالاضافة الى تعقيد الخوارزمية. تم تقييم الاداء لعدة حالات مختلفة وذلك 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 ومتوسط مربع الخطأ ولكن بيئة القناة لها تأثير أوضح على أداء الخوارزميتين. خوارزمية مربع المتوسط الاصغر ذو الخطوة المتغيرة الحجم تمتاز باداء افضل من خوارزمية مربع المتوسط الاصغر في كل الحالات ولكنها تحتاج الى عمليات جمع وضرب اكثر من خوارزمية مربع المتوسط الاصغر ذو الخطوة المتغيرة الحجم.

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# List of Symbols

| Symbol         | Description                                |
|----------------|--|
| $y(n)$         | 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                           |
| $TC$           | coherence time                             |
| $\nu_{rms}$    | root mean square value 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 $m$           |
| $\hat{W}(m)$   | 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 TelecommunicationSystem                  |
| VSS-LMS | Variable Step Size Least Mean Square                      |