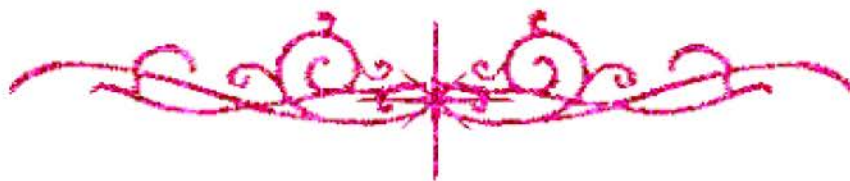


بسم الله الرحمن الرحيم





شبكة المعلومات الجامعية التوثيق الالكتروني والميكروفيلم



جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

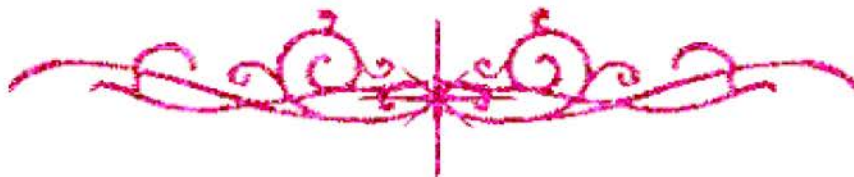
قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



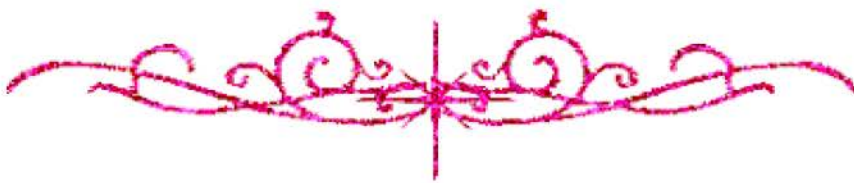
يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



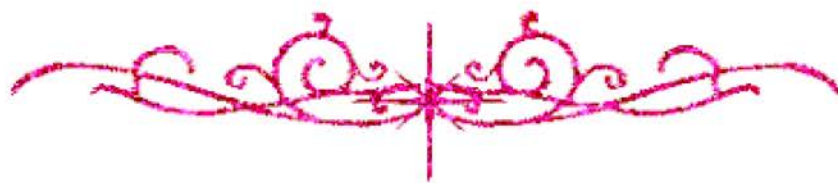


بعض الوثائق الأصلية تالفة





بالرسالة صفحات
لم ترد بالأصل



621, 381

B1V1V9

STUDY OF CHANNEL ESTIMATION ALGORITHMS FOR OFDM BASED WiMAX 802.16 SYSTEMS

By

Radiya Ali Mahmoud Mohamed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of

Master of Science

In

Electronics and Electrical Communications Engineering

Faculty of Engineering, Cairo University

Giza, Egypt

November, 2006

100 21 12

STUDY OF CHANNEL ESTIMATION ALGORITHMS FOR OFDM BASED WiMAX 802.16 SYSTEMS

By

Radiya Ali Mahmoud Mohamed

A Thesis Submitted to the
Faculty of Engineering at Cairo University

In Partial Fulfillment of the
Requirements for the Degree of

Master of Science

In

Electronics and Electrical Communications Engineering

Supervised by

Prof. Dr. Abdelwahab Fayed

Dr. Mohamed Khairy

Professor of Electronics and Communications Engineering.

Faculty of Engineering, Cairo University

Giza, Egypt

November, 2006

STUDY OF CHANNEL ESTIMATION ALGORITHMS FOR OFDM BASED WiMAX 802.16 SYSTEMS

By

Radiya Ali Mahmoud Mohamed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science

In

Electronics and Electrical Communications Engineering

Approved by the Examining Committee:



Prof. Dr. Safwat Mahroos Mahmoud, Member



Prof. Dr. Magdi Said El-Soudani, Member



Prof. Dr. Abdel-Wahab Fayez Hussein, Thesis Main Advisor

Faculty of Engineering, Cairo University

Giza, Egypt

November, 2006



Contents

Contents	i
LIST OF FIGURES	iii
LIST OF TABLES	v
LIST OF ABBREVIATIONS AND ACRONYMS	vi
ACKNOWLEDGEMENTS.....	viii
ABSTRACT	ix
Chapter 1	1
Introduction.....	1
Chapter 2	9
Principle and History of OFDM.....	9
2.1 Introduction	9
2.2 Origin of OFDM	9
2.3 Insertion of Cyclic Prefix for Current Form of OFDM	11
2.4 Conclusions	13
Chapter 3	16
3 Transmitter and receiver Design issues.....	16
3.1 Introduction	16
3.2 The block diagram components of the transmitter and receiver	18
3.2.1 Error control encoding	18
3.2.1.1 Randomization.....	18
3.2.1.2 Forward Error Correction (FEC)	20
3.2.1.2.1 Reed-Solomon codes.....	20
3.2.1.2.2 Convolutional codes.....	24
3.2.1.2.3 Forward Error Correction in 802.16	29
3.3 Modulation	31
3.4 Interleaving	32
3.4.1 Types of interleavers	33
3.4.1.1 Block Interleaver.....	33
3.4.1.2 Convolutional Interleaver.....	34
3.4.1.3 Helical interleavers.....	35
3.4.1.4 Pseudo-random interleavers.....	35
3.4.2 Interleaving in IEEE 802.16d	35
3.5 Pilot modulation	37
3.6 Rate ID encodings	37
Chapter 4	39
4 Channel estimation	39
4.1 Introduction	39
4.1.1 Basic Definitions:	39
4.2 OFDM Channel Estimation Techniques	44
4.2.1 Data aided channel estimation	45
4.2.1.1 Pilots Allocation for Data Aided Channel Estimation:	46
4.2.2 LS Estimation	51
4.2.3 Channel Estimation Techniques in Training Mode.....	53
4.2.4 Channel Estimation Techniques in Pilot Mode	54
4.2.5 Transform Domain Techniques	58
4.2.6 LMMSE Channel Estimation.....	60
4.2.7 Decision Directed Channel Estimation	62

4.3	Channel estimation algorithms applied in the system	65
4.3.1	Algorithm 1 (Least Square channel estimate LS)	67
4.3.2	Algorithm 2 (ML channel estimate)	70
4.3.3	Algorithm 3 (simplified linear MMSE estimate)	70
4.4	The Preamble	73
Chapter 5		75
5	Simulation Results	75
5.1	Simulation scripts	75
5.2	Simulation with AWGN channel	77
5.3	Simulation with Rayleigh fading channel	81
5.4	Simulation of preamble subcarriers number	89
5.5	Conclusion	91
Chapter 6		93
6	Conclusions and Future Work	93
6.1	Conclusions	93
6.2	Future work	95
Appendix A		107
A.1	Derivation of the Least-Squares solution	107
A.2	Derivation of MMSE	108
A.3	Derivation of ML	109

LIST OF FIGURES

Figure 1 Global Wireless Standards.	3
Figure 2 compares a base band serial data transmission system with an OFDM system[7].....	11
Figure 3 Comparison of transmitted waveforms: (a) Baseband serial data transmission System; and (b) OFDM system [7].....	12
Figure 4 Instantaneous impulse response of a frequency selective fading channel [7].....	12
Figure 5 Transmitted signals: (a) no guard interval insertion; (b) guard interval insertion; and (c) guard interval insertion with cyclic prefix [7].	14
Figure 6 Received signals: (a) no guard interval insertion; (b) guard interval insertion; and (c) guard interval insertion with cyclic prefix [7].	15
Figure 7 802.16a Physical Layer Block Diagram [8]	18
Figure 8 Pseudo-Random Binary Sequence (PRBS) for data randomization [9]	19
Figure 9 OFDM randomizer downlink initialization vector [9]	19
Figure 10 OFDM randomizer uplink initialization vector [9]	19
Figure 11 typical Reed Solomon code	21
Figure 12 typical Reed-Solomon codeword	22
Figure 13 Convolutional encoder of rate 1/2 [9].....	25
Figure 14 Hard- and Soft-decision decoding [14]	27
Figure 15 Puncturing patterns	29
Figure 16 BPSK, QPSK, 16-QAM and 64-QAM constellations [9].....	32
Figure 17 Bit-write and read structure for a 8x6 block interleaver [13].	34
Figure 18 Basic structure of a convolutional interleaver [13].	35
Figure 19 Helical interleavers	35
Figure 20 the initialization sequences of the downlink and uplink [9]	37
Figure 21 channel estimation effect [17].....	40
Figure 22: Time and frequency domain channel representation for OFDM based systems.	41
Figure 23 channel estimation techniques	42
Figure 24: Typical training symbols and pilot subcarriers arrangement.	46
Figure 25: Typical noisy CIR samples.	59
Figure 26 Proposed preamble structure	66
Figure 27: Amplitudes of the BPSK preamble symbol with only even subcarriers having non-zero amplitudes and null guard bands present at both ends of the symbol.....	66
Figure 28 Block diagram of the transmitter of physical layer of 802.16.....	75
Figure 29 Block diagram of the receiver of physical layer of 802.16	75
Figure 30 the block diagram of the transmitter.....	77
Figure 31 BER for BPSK, QPSK, 16-QAM, and 64-QAM.....	78
Figure 32 BER for BPSK, QPSK, 16-QAM, and 64-QAM taking G into consideration.....	79
Figure 33 BER for BPSK, QPSK, 16-QAM, and 64-QAM with coding	80
Figure 34 BER of BPSK, QPSK, 16QAM and 64QAM with coding and taking guard interval	81
Figure 35 BER of Raleigh fading channel perfect Estimation.....	82
Figure 36 BER performance of LS in time domain	83

Figure 37 BER performance of different simplification method of MMSE	84
Figure 38 BER performance of MMSE and LS in time domain	85
Figure 39 BER performance of ML and LS with linear interpolation RateID-0	86
Figure 40 Different symbol No for LS in time domain.....	87
Figure 41 Different interpolation methods for SLMMSE estimation algorithm	88
Figure 42 BER performance of Reed Solomon code	89
Figure 43 effect of decreasing the subcarriers number.....	90
Figure 44 effect of decreasing the subcarriers number over frequency domain channel estimation	91