AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics and Communications Engineering Department

Robust Channel Estimation Technique for OFDM Systems

A Thesis

Submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in

Electronics and Communications Engineering

Submitted by

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering).

The work included in this thesis was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier transmission technique in wireless environments, and can be seen as a multi-carrier digital modulation or multi-carrier digital multiplexing one as well. A large number of orthogonal sub-carriers are used to transmit information. OFDM systems have high utilization of the frequency spectrum and satisfactory capabilities of reducing multi-path inference. So, OFDM has been considered as one of the core techno-logies of 4th generation (4G) wireless communication systems.

Channel estimation plays a very important role in OFDM systems. It can generally be separated into two methods: pilot-based channel estimation and blind channel estimation. Pilot-based channel estimation, which is the focus of this thesis, estimates the channel information by obtaining the impulse response from all sub-carriers by pilot. Compared to blind channel estimation, which uses statistical information of the received signals and is not considered in this thesis, pilot-based channel estimation is a practical and effective method.

This thesis covers the basic principles of the OFDM system, system construction and the advantages and disadvantages of OFDM systems are considered also. It also offers a brief overview on signal propagation, channel parameters and the basic principles of channel estimation in OFDM systems.

The great challenge of channel estimation methods is to compromise between low complexity and high performance. In this thesis three improved methods of channel estimation are introduced. These methods are based on pilot-aided OFDM system with the arrangement employed in the DVB-T2 standard in time-varying frequency-selective fading channels. The first and second proposed methods (low complexity and improved low complexity methods, respectively) are modified methods based on the Domain Transform Least Square Estimation (DTLSE) method; they reduce the computational complexity by avoiding the use of the matrix inversion. The estimation matrix size for obtaining Channel Impulse Response (CIR) depends only on the length of the channel rather than the number of pilot sub-carriers or the size of OFDM symbols.

The third proposed method (high performance method) is based on a combination of the proposed low complexity method and the Two Dimensional Linear Interpolation (2-DLI) method. Similar to the previously proposed methods, the estimation matrix size for obtaining CIR depends only on the length of the channel. The three proposed methods are compared with three other methods: the DTLSE, 2-DLI and Minimum Mean Squared Error (MMSE). The first and second proposed methods prove to be less complex, with less computational load than the DTLSE and MMSE methods, and have higher robustness to Doppler shifts than the 2-DLI method. The second method also, proves to give BER performance comparable to MMSE method. The third method offers lesser complexity than the MMSE method, and a BER performance close to it and substantially better than the first proposed, DTLSE and 2-DLI methods.

Keywords:

The second generation for Digital Video Broadcasting - Terrestrial system (DVB-T2) , Domain Transform Least Square Estimation (DTLSE) , Two Dimensional Linear Interpolation (2-DLI) , Minimum Mean Square Estimation (MMSE).

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Papers Extracted from this Thesis

The First Paper

Ahmed H.Eldieb, Mona Z.Saleh and Salwa Elramly, "A Comparative Study of Channel Estimation Techniques for OFDM in DVB-T2", International Journal of Computer Applications (IJCA), April 2014, Volume 91 – No.14.

The Second Paper

Ahmed H.Eldieb, Mona Z.Saleh and Salwa Elramly, "An Improved Technique of Channel Estimation for OFDM in DVB-T2", International Journal of Computer Applications (IJCA), June 2014, Volume 96 – No.16.

The Third Paper

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To my mother, my father and my wife: you have been my constant companion and the rock upon which my successes have been built. Truly, I could not have done it without you. Thank you, from the bottom of my heart.

Contents

CHAPTER 3: Propagation and Fading in the Wireless Channel