A Comparative Study on Channel Estimation in Single and Multicarrier Transmission Systems

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Abstract-Nowadays, OFDM technology, as a multi-carrier modulation plan, has been shown to offer an alluringly high spectral efficiency and efficient research. The principle of this study was to research the exhibitions of different block channel estimators over multicarrier systems. The performance of different channel estimation methods for transmission systems with at least one transmits radio wires. For a transmitter assorted variety OFDM system, we can't utilize a similar channel estimation procedures used for a solitary transmit reception antenna system, because of the obstruction at the collector caused by the various transmit radio wires. In this investigation, creator tended to the channel estimation issue of single-input multiple output (SIMO) and multiple input multiple output (MIMO) systems. This exploration presents a survey of literature on channel estimation in single and multicarrier transmission approaches.

Keywords-OFDM, MIMO , Channel Estimation, Pilot Channel Estimation, Single and Multicarrier Transmissions.

I. INTRODUCTION

Nowadays, telecommunication services demand high data rates with reliability. However, to achieve high data rates, it is necessary to use a wide spectral bandwidth, which makes the system economically unfeasible. MIMO systems use multiple antennas to transmit and to receive signals. The multiple signals transmitted and the multiples replicas obtained in the receiver can be combined to increase the robustness (diversity) or the data rate (multiplexing).Orthogonal Frequency Division Multiplexing technique (OFDM) are commonly used to overcome the ISI(Inter Symbol Interference) introduced by multipath channel. High-data-rate wireless communication has become more and more important for military and commercial applications. Orthogonal frequency division multiplexing (OFDM) seems to be a promising solution for increasing a communication system's data rate by utilizing the available bandwidth in the most efficient way. Furthermore, the use of multiple receive and transmit antennas greatly increases the channel capacity and the performance over frequency-selective channels. Orthogonal frequency division multiplexing (OFDM) has emerged as an attractive technique for achieving high-bit-rate data transmission with high bandwidth efficiency in frequency-selective multipath fading channels.

Channel Estimation methods are generally divided into two groups: block-type and comb-type. In a block-type channel estimation method, all the sub-carriers in an OFDM block are used as pilot tones, and the OFDM block is transmitted periodically. In a comb-type channel estimation method, some of the sub-carriers are used as pilot tones in each of the OFDM blocks transmitted. In the block-type case, since all the sub-carriers are used to transmit pilot tones, it is possible to obtain an accurate estimate of the channel coefficients. In subsequent blocks, author can track variations of the channel coefficients by generating reference symbols. This increases the computational complexity of the channel estimator. In a comb-type channel estimation algorithm, an interpolation method must be used in order to estimate the frequency response of the channel at all sub-carrier frequencies. The interpolation error can be reduced by increasing the number of pilot sub-carriers, but this also decreases the bandwidth efficiency.

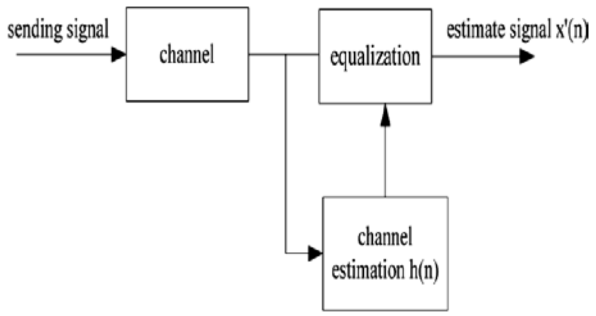

Fig. 1 Block diagram of channel estimation.

The combination of MIMO with OFDM technology provides a promising candidate for next generation fixed and mobile wireless systems. In practice for coherent detection, however, accurate channel state information in terms of Channel Impulse Response (CIR) or Channel Frequency Response (CFR) is critical to guarantee the diversity gains and the projected increase in data rate. Like OFDM systems, the MIMO-OFDM systems have a great deal of sensitivity toward synchronization errors. Again, according to the increase in number of unknowns, estimating the channel in these systems is more complex than estimating channel in single antenna system. Channel estimation is the process of characterizing the effect of the physical medium on the input sequence. It is an important and necessary function for wireless systems. Even with a limited knowledge of the wireless channel properties, a receiver can gain insight into the data sent over by the transmitter. The main goal of channel estimation is to measure the effects of the channel on known or partially known set of transmissions. MIMO-OFDM systems are especially suited for channel estimation.

II. PILOT-BASED CHANNEL ESTIMATION TRANSMISSION SYSTEM

In this type, OFDM symbols with pilots at all subcarriers (referred as pilot symbols) are transmitted periodically for channel estimation. For a block fading channel, where the channel is constant over a few OFDM symbols, the pilots are transmitted on all subcarriers in periodic intervals of OFDM blocks. This type of pilot arrangement is called the block type arrangement. Using these pilots, a time-domain interpolation is performed to estimate the channel along the time axis. Since pilot tones are inserted into all subcarriers of pilot symbol with a period in time, the block-type pilot arrangement is suitable for frequency-selective channels. For the fast-fading channels, however, it might incur too much overhead to track the channel variation by reducing the pilot symbol period.

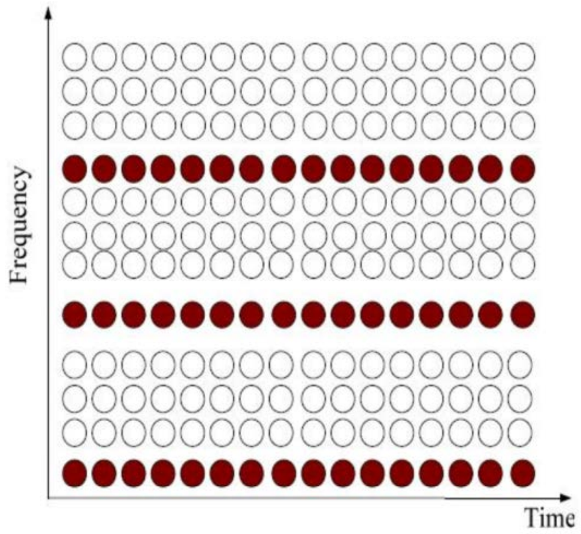

Fig. 2 Pilot Arrangement in OFDM System.

Pilot symbols or training symbols can be used for channel estimation; usually providing a good performance. The conventional training based methods. The used to estimate the channel by sending first a sequence of OFDM symbols, so called preamble which is composed of known training symbols. Then the Channel State Information (CSI) is estimated based on the received signals corresponding to the known training OFDM symbols prior to any data transmission in a packet. In the context of pilot assisted channel estimation scheme, training data that is known a priori at the receiver is transmitted along with the message data from the transmitter.

Single-carrier Transmission

When the system data rate is not too high, and of interference between symbols caused by multipath signal is not particularly serious, the single-carrier transmission system is normally used as is shown in Fig. 3, where the g(t) is matching filter. Then an appropriate equalization algorithm could be used to allow the system to work properly. But for broadband services of the higher rate data transmission.

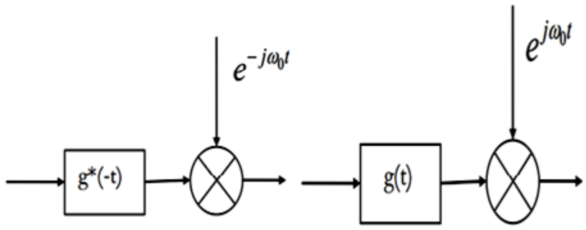

Fig.3 Frame of the single carrier.

Multi-carrier Transmission

Multi-carrier transmission system is a method of transmitting data by splitting it into several components, and sending each of these components over separate carrier signals. The individual carriers have narrow bandwidth, but the composite signal can have broad bandwidth. The advantages of multi-carrier transmission system include relative immunity to fading caused by transmission over more than one path at a time (multipath fading), less susceptibility than single-carrier systems to interference caused by impulse noise, and enhanced immunity to inter-symbol interference. Limitations include difficulty in synchronizing the carriers under marginal conditions, and a relatively strict requirement that amplification be linear. Fig. 4 shows the basic structure of multi-carrier system schematic.

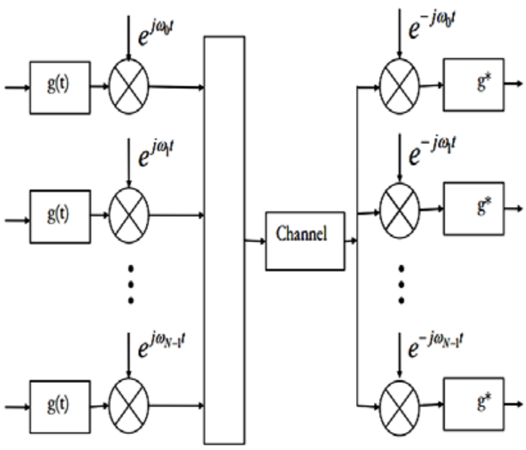

Fig. 4 Frame of Multi Carriers.

III. LITERATURE SURVEY

Sr. No.	Title	Author	Year	Approach
1	Optimal pilot design for channel estimation in single/multicarrier block transmission systems	M. Majumder, A. Kudeshia and A. K. Jagannatham	2017	This paper proposes a novel approach for optimal pilot sequence design for channel estimation in single carrier (SC) and multi carrier (MC) block transmission systems over frequency selective channels
2	Partial pilot transmission for self-interference channel estimation in full-duplex MIMO systems	K. Min, S. Park and S. Choi	2017	This paper proposes a partial pilot transmission method for self-interference (SI) channel estimation in full-duplex multiple-input multiple-output (MIMO) systems
3	Integer Frequency Offset Estimation for Dynamic Lattice Multicarrier Transmission System over Time-Varying Rayleigh Fading Channel,	K. Xu, W. Xie, Y. Xu and D. Zhang	2016	In this paper, author study the integer carrier frequency offset (ICFO) estimation problem for dynamic lattice multicarrier transmission (DLMT) system over time-varying rayleigh fading channel
4	Generalized optimal pilot allocation for channel estimation in multicarrier systems,	F. Rottenberg, F. Horlin, E. Kofidis and J. Louveaux	2016	This paper addresses the design of MSE-optimal preambles for multicarrier channel estimation under a maximum likelihood or minimum mean squared error criterion.
5	Analysis and Design of Channel Estimation in Multicell Multiuser MIMO OFDM Systems,	P. Xu, J. Wang, J. Wang and F. Qi	2015	This paper investigates the uplink transmission in multicell multiuser multiple-input multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM) systems.
6	Optimised Pilot Pattern for Dynamic Spectrum Access Multicarrier Systems,	E. Golovins and N. Ventura,	2010	Author propose an adaptive algorithm to construct a suboptimal pilot pattern, which minimises channel estimation error variance and can incorporate any restrictions on the transmit subcarriers.
7	Optimal pilot pattern design for dynamic spectrum access MIMO multicarrier systems	E. Golovins and N. Ventura,	2009	This paper addresses design of the optimal pilot pattern for MIMO-MC CRs. author consider pilot sequence precoding, which leads to the best channel estimation accuracy.

M. Majumder, A. Kudeshia and A. K. Jagannatham [1] This paper proposes a novel approach for optimal pilot sequence design for channel estimation in single carrier (SC) and multi carrier (MC) block transmission systems over frequency selective channels. The training design is based on minimizing the Bayesian Cramer-Rao bound (BCRB) for mean square error (MSE) of channel estimation which also employs the prior knowledge of the channel in conjunction with the receiver noise covariance subject to a total transmit power constraint. The proposed scheme derives the optimal pilot sequence which is applicable to all four block transmission systems i.e. single carrier zero padding (SC-ZP), multi-carrier zero padding (MC-ZP), single carrier cyclic prefix (SC-CP) and multi-carrier cyclic prefix (MC-CP) systems. Thus, the proposed framework and results derived are general with wide applicability. Simulation results are presented to show the improved performance of the proposed pilot design scheme in comparison to a conventional pilot design, in terms of both the mean square error (MSE) and bit error rate (BER).

K. Min, S. Park and S. Choi [2] This paper proposes a partial pilot transmission method for self-interference (SI) channel estimation in full-duplex multiple-input multiple-output (MIMO) systems. In the proposed partial pilot transmission method, pilots for estimating the SI channel are transmitted in part for the total transmit antennas. For the channels where the pilots are not transmitted, the previously estimated SI channels are utilized. Compared to the conventional method where pilots are transmitted for the whole transmit antennas, even if the partial pilot transmission method has the increased SI channel estimation error, the proposed pilot transmission method can achieve about a 1 bps/Hz gain in terms of the ergodic achievable rate.

K. Xu, W. Xie, Y. Xu and D. Zhang [3] In this paper, we study the integer carrier frequency offset (ICFO) estimation problem for dynamic lattice multicarrier transmission (DLMT) system over time-varying rayleigh fading channel. Firstly, a novel preamble structure based on two constant amplitude zero auto-correlation (CAZAC) sequences is designed for DLMT system. The proposed preamble structure is named as dual-CAZAC preamble. Then, by using the designed dual-CAZAC preamble, a weighted cross ambiguity function (WCAF) based ICFO estimation algorithm is proposed. Simulation results show that the proposed WCAF based ICFO estimation algorithm can mitigate the impact of time-varying multipath rayleigh fading channel and outperforms traditional ICFO estimator on the correct estimation probability performance.

F. Rottenberg, F. Horlin, E. Kofidis and J. Louveaux [4] This paper addresses the design of MSE-optimal preambles for multicarrier channel estimation under a maximum likelihood or minimum mean squared error criterion. The derived optimality condition gives insight on how to allocate the pilots that compose the preamble. While many papers show that equispaced and equipowered allocation is optimal, the generalized condition demonstrates that there exist many different configurations that offer the same optimal performance. Furthermore, the condition applies not only to maximum likelihood but also to minimum mean squared error channel estimation. An application of the generalized condition in the presence of inactive subcarriers (virtual subcarriers problem) is shown such that a non equispaced allocation can achieve the same optimal performance as if an equispaced one could be used.

P. Xu, J. Wang, J. Wang and F. Qi [5] This paper investigates the uplink transmission in multicell multiuser multiple-input multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM) systems. The system model considers imperfect channel estimation, pilot contamination (PC), and multicarrier and multipath channels. Analytical expressions are first presented on the mean square error (MSE) of two classical channel estimation algorithms [i.e., least squares (LS) and minimum mean square error (MMSE)] in the presence of PC. Then, a simple H-infinity (H-inf) channel estimation approach is proposed to have good suppression to PC. This approach exploits the space-alternating generalized expectation-maximization (SAGE) iterative process to decompose the multicell multiuser MIMO (MU-MIMO) problem into a series of single-cell single-user single-input single-output (SISO) problems, which reduces the complexity significantly. According to the analytic results given herein, increasing the number of pilot subcarriers cannot mitigate PC, and a clue for suppressing PC is obtained. It is shown from the results that the H-inf has better suppression capability to PC than classical estimation algorithms. Its performance is close to that of the optimal MMSE as the length of channel impulse response (CIR) is increased. By using the SAGE process, the performance of the H-inf does not degrade when the number of antennas is large at the base station (BS).

E. Golovins and N. Ventura, [6] Optimal training design for wireless multicarrier communication systems has recently become an active research area. However, the existing solutions are not applicable to dynamic spectrum access systems as they do not take into account the restrictions on pilot subcarrier placement or the interference impact on the channel estimation performance. In such a case the problem of optimal pilot-assisted multicarrier transmission has to be reformulated, taking into account deactivated subcarriers and second-order interference statistics. In this paper, we propose an adaptive algorithm to construct a suboptimal pilot pattern, which minimises channel estimation error variance and can incorporate any restrictions on the transmit subcarriers.

E. Golovins and N. Ventura, [7] One of the serious challenges, which hamper application of multiple-input multiple-output (MIMO) multicarrier (MC) transmission systems in the cognitive radio (CR) environments, is the synthesis of reliable pilot signals, which can be used for the CR channel sounding. This paper addresses design of the optimal pilot pattern for MIMO-MC CRs. The principal novelty of this work in contrast to the previous ones is that the proposed solution is optimal from both performance and receiver complexity standpoint. To be more specific, we consider pilot sequence precoding, which leads to the best channel estimation accuracy, ensured by the optimal pilot power distribution and joint estimation of the second-order channel response statistics.

IV. PROBLEM IDENTIFICATION

Pilot-based channel estimation of OFDM system is discussed in detail. The research first introduces the OFDM wireless communication technology, history, basic principles, advantages, disadvantages and application prospects. Then, the wireless multipath channel effect on the OFDM system is analyzed theoretically, and the multipath fading channel model is given. There are two main problems in designing channel estimators for wireless OFDM systems. The first problem is the arrangement of pilot information, where pilot means the reference signal used by both transmitters and receivers. The second problem is the design of an estimator with both low complexity and good channel tracking ability. The problems are interconnected.

V. CONCLUSION

In this work an extensive review of literature has presented. As a development of this survey, the observation samples can be further processed to obtain the pure pilot information after the decoding Generally speaking, channel estimation can be accomplished by using data statistics (blind) or inserting pilots that are a priori known (pilot-assisted). Nevertheless, blind estimation algorithm usually employs high-order statistics of the received samples and requires long data records to attain reliable accuracy, which however lowers its applicability in a time-varying channel. Multiple-Input Multiple-Output (MIMO) Orthogonal Frequency- Division Multiplexing (OFDM) transmission systems under the general case of doubly-selective channels. In particular, I investigate an optimal power distribution among pilot- and data-symbols and the influence of such a power distribution on the performance of the transmission system.

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