LS Codes Based Multipath Channel Estimation
for MIMO-OFDM Systems

*김원섭, *박재준, *정현규, **이혁재
*한국전자통신연구원 이동통신연구단, **한국정보통신대학교
{*topsop, *jjpark, *hkchung}@etri.re.kr, {**hjlee}@icu.ac.kr

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*Won-Sop Kim, *Jae-Joon Park, *Hyun-Kyu Chung, **Hyuck-Jae Lee

*Electronics and Telecommunications Research Institute, ** Information and Communications University

Mobile Telecommunication Research Laboratory

요 약

MIMO-OFDM system is regarded as one of the promising schemes in high data-rate wireless communication. In this paper, efficient channel estimation techniques based on Loosely Synchronous (LS) codes are proposed for MIMO-OFDM systems. Since LS codes have perfect auto-correlation and cross-correlation functions within certain vicinity of the zero shifts, multiple antennas and multipath signal interference can be reduced substantially. Simulation results show that the first proposed technique outperforms least square and linear minimum mean square error (LMMSE) estimators and the second proposed technique outperforms least square estimator and has slightly inferior performance as compared with LMMSE estimator.

I. INTRODUCTION

The requirement of high-data rate services in mobile communication systems becomes more and more prevalent in recent years. MIMO systems have shown their potential by providing higher data-rate and diversity gain with scheme as spatial multiplexing or Bell Lab Layered Space-Time (BLAST) and Space-Time Block Coding (STBC) [1] respectively. OFDM is commonly used for high data rate wireless communication due to its inherent error susceptibility. MIMO-OFDM system is regarded as one of the promising schemes in high data-rate wireless communication. However, since channel characteristics are not perfectly known at the receiver, reliable channel estimations are needed to take the advantages of the MIMO-OFDM systems. For the SISO-OFDM systems, least square [4] and LMMSE [4] estimators can be applied to estimate channel. In MIMO-OFDM systems, these techniques are inadequate for channel estimation, because signals from other transmission antennas act as interference.

LS codes [6] based on Golay complementary pairs (GCP) [5] have the zero correlation zone (ZCZ) or Interference Free Window (IFW). It is proposed that the multiple antennas and multipath interference can be reduced significantly by utilizing the ZCZ or IFW.

In this paper, we propose efficient channel estimation techniques for MIMO-OFDM systems by using LS codes as training sequences. Since LS codes have perfect auto-correlation and cross-correlation functions within certain vicinity of the zero shifts, multiple antennas and multipath signal interference can be reduced substantially.

This paper is organized as follows. In section II, a system model of MIMO-OFDM systems is described. In section III, properties of LS codes are described. In section IV, proposed channel estimation techniques are described. Finally, Section V and VI give simulation results and conclusions respectively.

II. SYSTEM MODEL

MIMO-OFDM systems having k synchronous Alamouti system [1] blocks at the transmitters are shown in Fig. 1. The output over two consecutive periods at the jth receive antenna, $Y_{1,j}(k)$
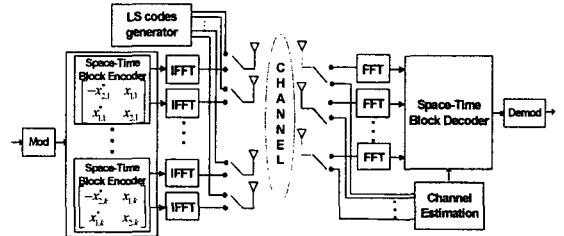

Fig. 1. A block diagram for a MIMO-OFDM system based on LS codes channel estimation

and $Y_{2,j}(k)$, for $k=1,2,..,N$ could be written as,

$$Y_{1,j}(k) = \sum_{i=1}^{k} \left\{ H_{1,j}^{i}(k)X_{1,i}(k) + H_{2,j}^{i}(k)X_{2,i}(k) \right\} + W_{1,j}(k) \quad (1)$$

$$Y_{2,j}(k) = \sum_{i=1}^{k} \left\{ H_{2,j}^{i}(k)X_{1,i}^{*}(k) - H_{1,j}^{i}(k)X_{2,i}^{*}(k) \right\} + W_{2,j}(k)$$

where $\left[X_{1,i}(k), X_{2,i}(k) \right]$ are transmitted from the ith block simultaneously during the first symbol period, $\left[-X_{2,i}^{*}(k), X_{1,i}^{*}(k) \right]$ are transmitted from the ith block during the second symbol period, $H_{1,j}^{i}$ and $H_{2,j}^{i}$ denote the channel frequency responses of the ith transmission block and the jth receive antenna respectively, $W_{1,j}(k)$ and $W_{2,j}(k)$ represent the frequency response of AWGN.

III. LOOSELY SYNCHRONOUS CODES

A. Properties of uncorrelated LS codes in interference free window

LS codes are defined as the combination of C and S subsequences, a Golay complementary pair, with zeros inserted to avoid overlapping between the two subsequences. As a result of inserted zeros, LS codes have shown that aperiodic auto-correlation sidelobes and cross-correlations are zero within IFW W_0. Fig. 2 shows auto-correlation and cross-correlation property of a mate with length $N = 64$ and IFW $W_0 = 32$.