Chapter 6

Adaptation of Algebraic Space Time Codes to Frequency Selective Channel

Ahmed Bannour
Higher School of Communications of Tunis Sup’Com, Tunisia

Mohamed Lassaad Ammari
Higher School of Communications of Tunis Sup’Com, Tunisia

Yichuang Sun
University of Hertfordshire, UK

Ridha Bouallegue
Higher School of Communications of Tunis Sup’Com, Tunisia

ABSTRACT

The Algebraic Space Time Codes (ASTC) are constructed based on cyclic algebras; they showed a good spectral efficiency, a full diversity, and a full rate under non selective channel condition. However, the radio - mobile channel is a selective channel whose features vary during the time. This selectivity is owed to the multi-path phenomenon and generates interferences between symbols (IES). The overall objective of this chapter is to proof that ASTC is adapted to channel selectivity, in order to analyze and improve its performances in wide-band system.

INTRODUCTION

Communication using multiple antennas at both transmitter and receiver ends achieve a very high spectral efficiency over wireless channels. Therefore, a significant interest has been shown in developing systems that offer both high capacity and high data speed using multiple antennas. A variety of space-time codes have been proposed accordingly in the literature, among which a new family of codes based on cyclic division algebras are of particular interest.

DOI: 10.4018/978-1-4666-1797-1.ch006
Adaptation of Algebraic Space Time Codes to Frequency Selective Channel

The so called Quaternionic Space Time codes have good performance but they suffer from the non-uniform distribution of the energy in the codeword. To alleviate this problem, a new family of algebraic space time codes have been proposed in (J. C. Rekaya, 2005), which have a structure of full-rate and full diversity $2 \times 2, 3 \times 3, 4 \times 4$ and $6 \times 6$ space-time codes. These codes have a constant minimum determinant as the spectral efficiency increases. The name perfect space time codes, used for these codes, are suggested by the fact that they satisfy a large number of design criteria and only appear in a few special cases of the classical perfect error correcting codes, achieving the Hamming sphere packing bound. In this paper we will use $2 \times 2$ and $4 \times 4$ perfect codes.

Recently, there has been an increasing interest in providing high data rate services like video conference, multimedia over wideband channels. Algebraic Space Time Coding techniques, by their very nature, readily lend themselves to high data rate situations. Unfortunately, they require a flat fading channel to function correctly. Therefore, it becomes extremely necessary to harness their power for wideband systems.

Orthogonal frequency division multiplexing (OFDM) has been adopted in the wireless local area network (WLAN) standards IEEE 802.11a (ISO/IEC) and g (standard) due to its high spectral efficiency and ability to deal with frequency selective fading. The combination of OFDM with spectral efficient multiple antenna techniques makes the OFDM as good candidate to overcome the frequency selective problems for the perfect $2 \times 2$ and $4 \times 4$ ASTC codes.

BACKGROUND

Despite the attractive features of both OFDM and ASTC they are very sensitive to the transmitter and receiver synchronization imperfections (A. Bannour M. A., 2010) (A. Bannour M. A., 2011). Thus, the synchronization is crucial for ASTC-MIMO-OFDM-based systems. Frequency synchronization errors destroy the orthogonality among the subcarriers which results in inter-carrier interference (ICI) (Renfors, 2007) (B. Swami, 2005) (Schlegel, 2002) (Peeters, 2002). Therefore an accurate CFO estimation is essential for OFDM receiver design. Various carrier synchronization schemes have been proposed for SISO OFDM systems. Some schemes rely on pilot or preamble data (Moose, 1994) (Cox, 2007) (Santella, 2002) (Mengali, An improved frequency offset estimator for OFDM applications, 2002) (S. Hyoung-Kyu, 2000) (Reggiannini, 2005) and some use the inherent structure of the OFDM symbol in either frequency (U. Tureli H. L., 1997) or time domain (J. J. van de Beek, 2002). For multiple antenna OFDM, data-aided schemes are proposed for receiver diversity and MIMO in (Czylwik, p. 1999) and (Stuber, 2001), respectively. A blind method for receiver diversity combined with OFDM is proposed in (U. Tureli D. K., 2001).

MAIN FOCUS OF THE CHAPTER

In this chapter, we propose a new CFO estimator to mitigate the degraded performance of most existing CFO estimators in highly frequency-selective fading channels. The proposed estimator utilizes both time and frequency domain symbols, hence it can be considered as a hybrid time and frequency domain estimator. The proposed CFO estimation technique is applied for MIMO-OFDM systems employing algebraic space time coding schemes with a fixed common CFO among all transmit and receive antenna pairs. This assumption is justifiable because the antennas in MIMO systems usually share a single radio frequency oscillator. Moreover, the differences in Doppler shift between all transmit and receive antenna pairs are small (Giannakis, 2005). By assuming that the channel response remains approximately