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Performance of Golden encoded MIMO OFDM system with carrier frequency offset

Dr.C.Geetha Priya

ABSTRACT

This paper presents the performance of carrier Frequency offset estimation algorithm for golden encoded MIMO OFDM system. Basically Algebraic Space Time Code (ASTC) has three major encoding methods they are Golden, TAST and DAST encoding. But Golden encoder provides an efficient performance while compared with the TAST and DAST. Carrier frequency offset estimated for Golden code multiple input and multiple output (MIMO) Orthogonal frequency division multiplexing (OFDM) system. The orthogonal training sequence are simultaneously transmitted and received from multiple antennas. In the receiver side estimated the Carrier frequency offset (CFO), Golden code gives the efficient SNR vs. MSE compared with the Cramer Rao Lower Bound (CRLB).

Keyword-Algebraic Space Time Code (ASTC), Multi Input and Multi Output (MIMO), Orthogonal frequency division multiplexing (OFDM), Carrier frequency offset (CFO), Cramer Rao Lower Bound (CRLB).

1. Introduction

To improve the data rate and error free data transmission Algebraic Space Time Code are used. A golden encoding method is used to achieve a full rate and full diversity for transmission. Carrier frequency offset is estimated in the receiver side. SNR vs. MSE is compared with Golden encoded MIMO OFDM system and the theoretical CRLB.

The space time codes have good performance, but they suffer from the non-uniform distribution of the energy in the code word. To alleviate this problem, a new family of ASTCs has been proposed in [1] and [2], which have a structure of full-rate and full-diversity 2 × 2, 3 × 3, 4 × 4, and 6 × 6 space–time codes. These codes have a constant minimum determinant as spectral efficiency increases. The name perfect space–time codes, which is used for these codes, is 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, 2× 2 and 4 × 4 perfect codes are used.

Orthogonal frequency-division multiplexing (OFDM) has been adopted in the wireless local area network standards IEEE 802.11a [3] and g [4] due to its high spectral efficiency and ability to deal with frequency-selective fading. The combination of OFDM with spectrally efficient multiple-antenna techniques makes the OFDM a good candidate to overcome the frequency selective problems for the perfect 2× 2 and 4 × 4 ASTC codes.

Despite the attractive features of both OFDM and ASTC, they are very sensitive to transmitter–receiver synchronization imperfections [5]. Thus, the synchronization is crucial for ASTC-multiple-input–multiple-output (MIMO)-OFDM-based systems. Frequency synchronization errors destroy the orthogonality among the subcarriers, which results in inter carrier interference (ICI) [6]. Therefore, an accurate carrier frequency offset (CFO) estimation is essential for OFDM receiver design. Various carrier synchronization schemes have been proposed for single-input–single-output OFDM systems. Some schemes rely on pilot or preamble data [8]–[14], and some use the inherent structure of the OFDM symbol in either frequency [15] or time domain [16]. For multiple-antenna OFDM, data-aided schemes are proposed for receiver diversity and MIMO in [17] and [18], respectively. A blind method for receiver diversity combined with OFDM is proposed in [19].

2. System model

The system model consists of Algebraic Space Time Code encoder and decoder; Orthogonal Frequency Division Multiplexing modulator and demodulator; Multiple Input Multiple Output transmitting and receiving antennas. These models are explained in following sections.

A. MIMO OFDM MODEL

A multicarrier system can be efficiently implemented in discrete time using an inverse DFT (IDFT) to act as a modulator and an DFT to act as a demodulator. The transmitted data are the “frequency” domain coefficients and the samples at the output of the IDFT stage are “time” domain samples of the transmitted waveform. Fig.1 shows a typical ASTC MIMO-OFDM system for Golden Encoder.

Consider the baseband-equivalent ASTC-MIMO OFDM system, with *nt* transmit antennas and *nr* receive antennas, depicted in Fig. 1. The transmitted binary source sequence *sk* is quadrature phase-shift keying (QPSK) modulated. The QPSK symbols are then ASTC encoded.

B.GOLDEN ENCODER

Each information in the sequence of data at time n_i is encoded by the ASTC encoder into two stream constellations represented by the code word $X_{N_c} \times N_t$ where N_t refers to number of transmitted antennas and N_c is the number of used subcarriers

The code is a 1 × 128 STBC obtained using a division algebra, which is full rate, full diversity, and has a nonzero lower bound on its coding gain, which does not depend on the constellation size.
Code word in the form of 2×2 is written as:

$$X_{ni} = \frac{1}{\sqrt{5}} \begin{pmatrix} \alpha(v_{ni}(1)+\theta v_{ni}(2)) & \alpha(v_{ni}(3)+\theta v_{ni}(4)) \\ \bar{\alpha}(v_{ni}(3)+\bar{\theta} v_{ni}(4)) & \bar{\alpha}(v_{ni}(1)+\bar{\theta} v_{ni}(2)) \end{pmatrix} \quad (1)$$

Where,

$$\theta = \frac{1+\sqrt{5}}{2}; \qquad \bar{\theta} = \frac{1-\sqrt{5}}{2}$$

$$\alpha = 1 + i - i\theta; \bar{\alpha} = 1 + i - i\bar{\theta}$$

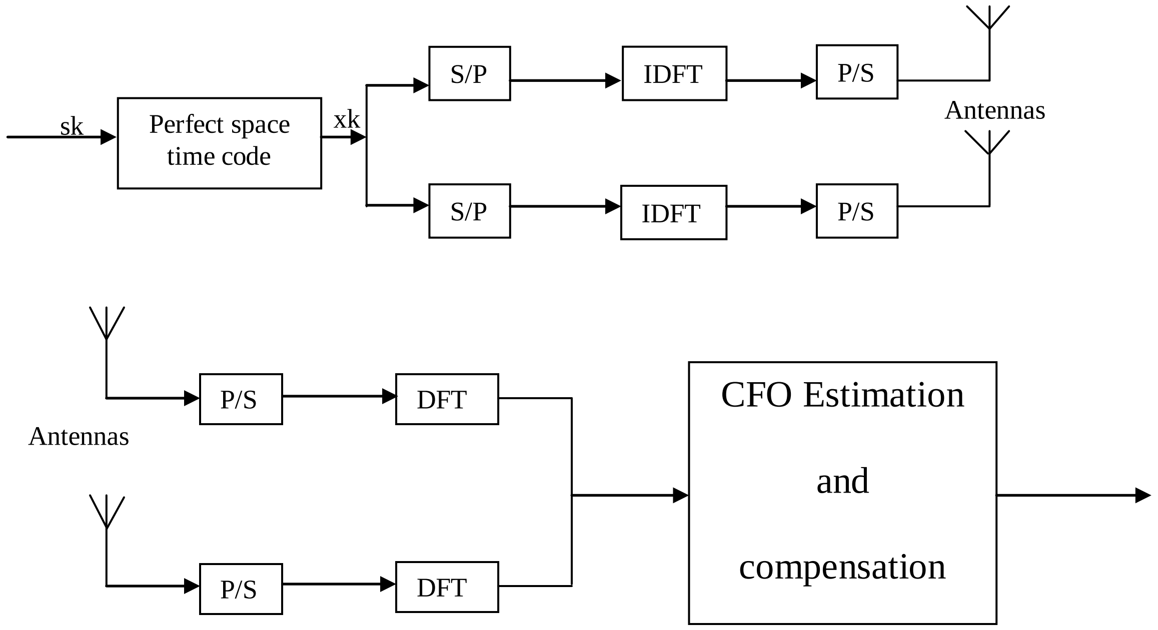

Fig 1. ASTC MIMO OFDM system for Golden Encoder

3. Carrier Frequency Offset Estimation Algorithm

In Carrier Frequency Offset estimation algorithm the first step is receiving the transmitted signal. The received signal has Carrier frequency offset and noise with it. The received signal r_x can be represented as given below.

$$r_x = (u_x . H_x) + w \qquad (2)$$

In this equation w is additive noise and H_x is the channel with the received signal. From this the Carrier Frequency Offset should be estimated. The following equations explain how the CFO is estimated from the received signal.

$$\hat{c} = r_x(e^{j\pi\Delta}) \qquad (3)$$

$$\hat{\Delta} = \angle\left(\sum_{0}^{N-1}\frac{\hat{c}}{r_x}\right) \qquad (4)$$

In the equation $\hat{c}$ the symbol has values less than 1. The Carrier Frequency Offset can be estimated from the equation and it is the estimated CFO. This estimation can be done with Golden encoders.

$$CRLB = \frac{n_c\sigma^2}{16\pi^{4n_r}} \qquad (5)$$

4. Simulation Results and Discussion

Consider an OFDM symbol with a total of N = 128 subcarriers and no virtual subcarriers. Here two antennas are used at both transmitter and receiver side. So, number of transmitter n_t is 2 and number of receiver n_r is 2. The data generated are in the form of a row vector and size if the vector is 1 × 128. The simulation results are as follows.

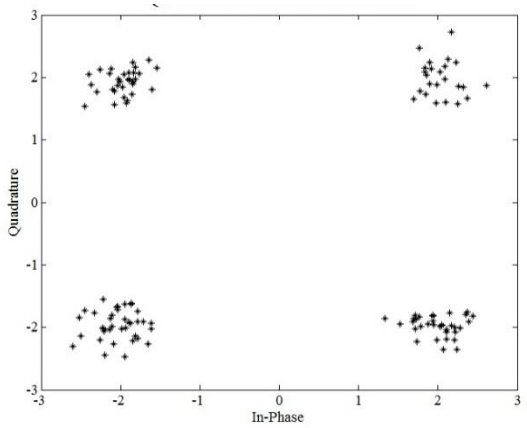

Fig 2. QPSK Constellation for 1 × 128 data

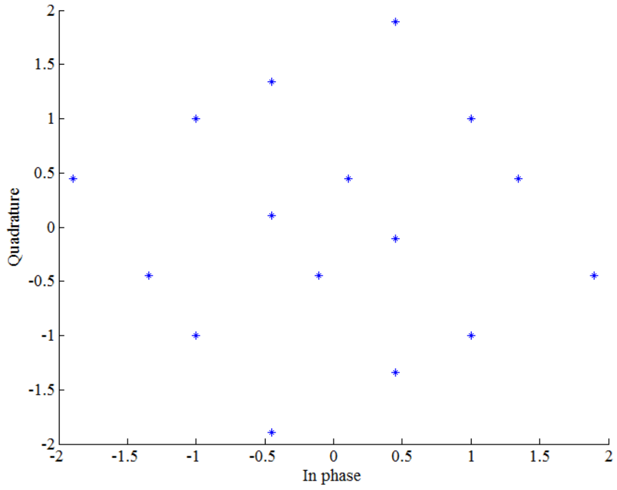

Fig 3. Constellation for Golden Encoder

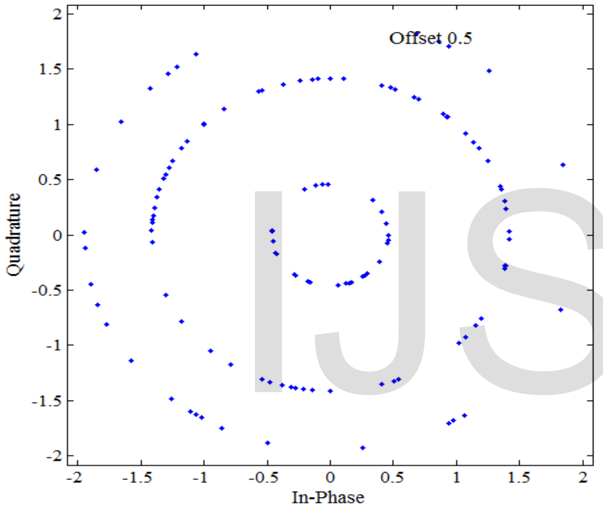

Fig 4. Golden Encoder with offset 0.5 subcarrier spacing

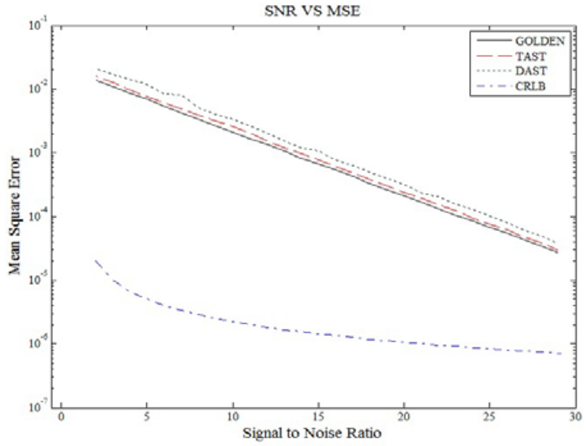

Fig 5. SNR Vs. MSE for ASTC Encoded MIMO OFDM

SNR	MSE		
	GOLDEN	TAST	DAST
0	0.02226	0.02446	0.03513
1	0.01690	0.01979	0.02588
2	0.01372	0.01596	0.02082
3	0.01076	0.01251	0.01676
4	0.00868	0.00971	0.01409
5	0.00690	0.00772	0.01185
6	0.00534	0.00602	0.00830
7	0.00426	0.00485	0.00803
8	0.00337	0.00393	0.00509
9	0.00263	0.00311	0.00405
10	0.00211	0.00253	0.00335
11	0.00163	0.00201	0.00264
12	0.00135	0.00152	0.00206
13	0.00106	0.00119	0.00151
14	8.2994E-4	9.6445E-4	0.00118
15	6.7159E-4	7.7450E-4	0.00107
16	5.3794E-4	6.0307E-4	7.7302E-4
17	4.2306E-4	4.8399E-4	6.3186E-4
18	3.2465E-4	3.8329E-4	5.0056E-4
19	2.6077E-4	3.0142E-4	3.8689E-4
20	2.0926E-4	2.3960E-4	3.1584E-4
21	1.6756E-4	1.9622E-4	2.3182E-4
22	1.3129E-4	1.5196E-4	2.0679E-4
23	1.0557E-4	1.2328E-4	1.5918E-4
24	8.4538E-5	9.3325E-5	1.2767E-4
25	6.7037E-5	7.4907E-5	1.0166E-4
26	5.4192E-5	6.2010E-5	8.1223E-5
27	4.2728E-5	4.7470E-5	6.0949E-5
28	3.4391E-5	3.7969E-5	4.8535E-5

Table 1. Performance Comparison of CFO estimation algorithm for Golden, TAST and DAST encoded MIMO OFDM system.

This results shows that the comparison with the Golden code SNR Vs. MSE ratio to the CRLB SNR Vs. MSE ratio. The result shows that the Golden Encoder is closely to Cramer-Rao lower bound plot.

5. Conclusion

This paper presented a new algebraic CFO estimation technique for MIMO-OFDM systems over AWGN channel employing ASTC Golden Encoder. The results of CFO estimation are perfect and by using Golden encoders full rate and full diversity are achieved. The simulated results shows that the Golden Encoder approaches to the theoritical Cramer-Rao lower bound .

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