

A Novel MIMO - OFDM Technique for Improving Wireless Communications System Performance based on SF-BC

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ABSTRACT

In this work, the author implemented a NOVEL technique of multiple input multiple output (MIMO) orthogonal frequency division multiplexing (OFDM) based on space frequency - block coding (SF-BC). Where, the implemented code is designed based on the QOC using the techniques of the reconfigurable antennas. The proposed system is implemented using MATLAB program, and the results showing best performance of a wireless communications system of higher coding gain and diversity.

Keywords

MIMO, OFDM, SF-BC, QOC.

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a modulation of multi carrier technique which has high spectral efficiency and higher data rates [1].

In OFDM, the fading channel of the frequency selective is transformed into several sub flat fading channels by the division of the channel bandwidth [2]. OFDM can be combined with MIMO to increase the capacity of the system and performance [3].

The capacity and reliability of wireless communications system can be increase by using the reconfigurable antennas too [4].

Therefor, the performance of the wireless systems can improve by using the reconfigurable antennas and designing a proper code [5].

In order to access the advantages of this technique, literature review are done and the efficient code must be design.

In [6], designed a MIMO based on the reconfigurable receiver antenna which achieved a diversity that equals to the product of the number of receive and transmit antennas, and the number of reconfigurable states of the receive antennas. Where, their gain diversity is possible only under the propagation that selected in the channel.

In [7], designed the system based on the reconfigurable transmitter and receiver antennas. Where, they could not achieve the diversity of the frequency between T_x and R_x .

In [8], used the space time coding to get the first frequency diversity in multipath environment.

In [9]–[10], they designed similar SF in MIMO OFDM system.

So, the SF codes that obtained can not achieved spatial and frequency diversities together.

Therefor in [11], they used a subcarrier technique to improve the diversity gain and minimize the complexity in the receiver side.

In [12], they used the mapping technique to exploit the full frequency but it does not ensure the full code.

BC that obtained the frequency diversity was designed [13], [14] and [5].

So, in the above works and many other similar works, the SF codes that proposed can not be able to achieve the full diversity in the MIMO OFDM reconfigurable antenna techniques.

2. TECHINQUE DESCRIPTION

In this work, the author implemented a coding to improve the performance of the MIMO - OFDM system.

His method include a code that is sent over T_x antennas, OFDM tones, and radiation states. In order to obtain state diversity, he configured each transmit antenna element to independently switch its radiation pattern to a direction that can be selected using criteria, e.g., to reduce the correlation of radiation states. The implemented code is based on the quasi orthogonal space time block codes (QOSTBC) [15]–[16].

This paper is prepared as follows. In Section 3, introduce the system model. In Section 4, discuss the SF – BC design. In Section 5, view the results. In Section 6, conclusions are presente.

3. SYSYTEM MODEL

Assume that the "MIMO-OFDM" proposed system is shown in Fig. 1.

In this system, the author assumed that the omni-directional antenna of receiver " M_r " is fixed radiation, and the OFDM modulation " N_c " and FSF channels with propagation paths " L " between each pair of M_t and M_r in each the state of radiation.

The channel IR between M_t i and receive M_r j in the p-th radiation state is:

$$h_p^{i,j}(\tau) = \sum_{l=0}^{L-1} \alpha_p^{i,j}(l) \delta(\tau - \tau_{l,p}), \quad (1)$$

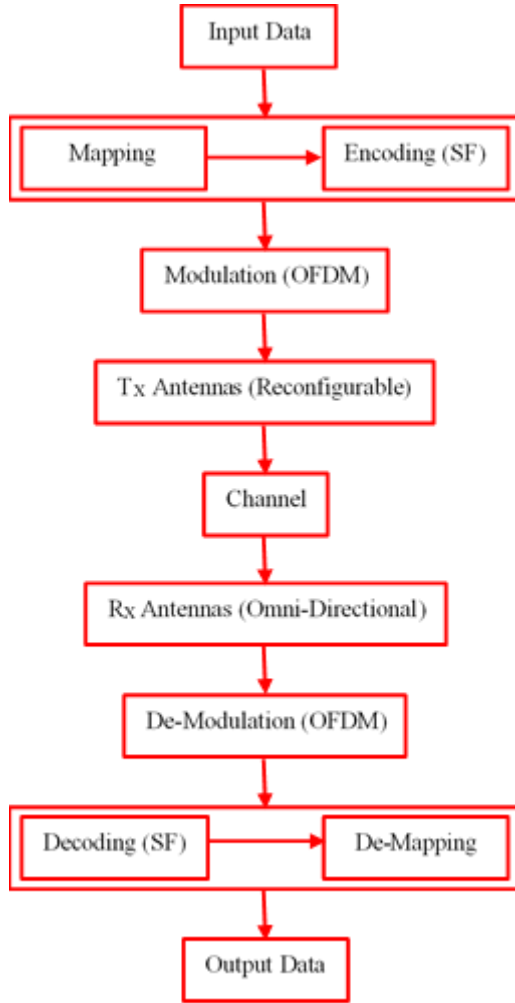


Fig.1 Block Diagram of the Proposed System.

The FR of the channel at the n -th subcarrier between M_t i and M_r j is:

$$H_p^{i,j}(n) = \sum_{l=0}^{L-1} \alpha_p^{i,j}(l) e^{-j2\pi n \Delta f \tau_{l,p}}, \quad (2)$$

The transmitted SF code, $C_p \in C_{M_t \times N_c}$, is:

$$C_p = \begin{bmatrix} c_p^1(0) & c_p^1(1) & \cdots & c_p^1(N_c - 1) \\ c_p^2(0) & c_p^2(1) & \cdots & c_p^2(N_c - 1) \\ \vdots & \vdots & \ddots & \vdots \\ c_p^{M_t}(0) & c_p^{M_t}(1) & \cdots & c_p^{M_t}(N_c - 1) \end{bmatrix}, \quad (3)$$

At the receiver, the received subcarrier and radiation signal can be written as:

$$y_p^j(n) = \sqrt{\frac{\gamma}{M_t}} \sum_{i=1}^{M_t} H_p^{i,j}(n) c_p^i(n) + z_p^j(n), \quad (4)$$

The received signal is:

$$\mathbf{y}_p = \sqrt{\frac{\gamma}{M_t}} \mathbf{H}_p \mathbf{c}_p + \mathbf{z}_p, \quad (5)$$

Where:

$$\mathbf{H}_p = \text{diag}\{\mathbf{H}_p(0), \mathbf{H}_p(1), \dots, \mathbf{H}_p(N_c - 1)\} \quad (6)$$

The P radiation states SF code is:

$$\mathbf{C} = [\mathbf{C}_1, \mathbf{C}_2, \dots, \mathbf{C}_P], \quad (7)$$

The over all radiation states of the received signals is:

$$\mathbf{y} = \sqrt{\frac{\gamma}{M_t}} \mathbf{H} \mathbf{c} + \mathbf{z}, \quad (8)$$

Where: \mathbf{c} is the channel matrix, and \mathbf{z} is the noise vector.

4. SF – BC DESIGN

In this section, the author present his proposed code. He designed the code based on the QOC. Where, the SF code is:

$$\mathbf{C}_p = [\mathbf{G}_p^{1T} \mathbf{G}_p^{2T} \cdots \mathbf{G}_p^{MT} \mathbf{0}_{N_c - M L M_t}^T], \quad (9)$$

Where:

$$\mathbf{G}_p^m = \text{col}\{\mathbf{X}_1, \mathbf{X}_2, \dots, \mathbf{X}_L\}, \quad (10)$$

Assume having $M_t = 2$, so:

$$\mathbf{A}(x_1, x_2) = \begin{bmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{bmatrix}, \quad (11)$$

So:

$$\mathbf{G}_p^m = \begin{bmatrix} \mathbf{A}(S_{2(p-1)L+1}^m, S_{2(p-1)L+2}^m) \\ \mathbf{A}(S_{2(p-1)L+3}^m, S_{2(p-1)L+4}^m) \\ \vdots \\ \mathbf{A}(S_{2pL-1}^m, S_{2pL}^m) \end{bmatrix} \quad (12)$$

In (12), can compute as:

$$\begin{bmatrix} S_1^m & S_3^m & \cdots & S_{2pL-1}^m \end{bmatrix}^T = \Theta \begin{bmatrix} s_1^m & s_3^m & \cdots & s_{2pL-1}^m \end{bmatrix}^T, \quad (13)$$

$$\begin{bmatrix} S_2^m & S_4^m & \cdots & S_{2pL}^m \end{bmatrix}^T = \Theta \begin{bmatrix} s_2^m & s_4^m & \cdots & s_{2pL}^m \end{bmatrix}^T,$$

There are many optimization methods can be used to find the objective function, such as: "the minimum Euclidean distance between constellation points".

For example, assume that the proposed system with these properties: $M_t = 2$, $P = 2$, and $L = 2$. Therefore, the C_1 and C_2 are:

$$C_1 = \frac{1}{4} \begin{bmatrix} S_1^1 & -S_2^{1*} & S_3^1 & -S_4^{1*} & \cdots & S_1^M & -S_2^{M*} & S_3^M & -S_4^{M*} \\ S_2^1 & S_1^{1*} & S_4^1 & S_3^{1*} & \cdots & S_2^M & S_1^{M*} & S_4^M & S_3^{M*} \end{bmatrix} \quad (14)$$

$$C_2 = \frac{1}{4} \begin{bmatrix} S_5^1 & -S_6^{1*} & S_7^1 & -S_8^{1*} & \cdots & S_5^M & -S_6^{M*} & S_7^M & -S_8^{M*} \\ S_6^1 & S_5^{1*} & S_8^1 & S_7^{1*} & \cdots & S_6^M & S_5^{M*} & S_8^M & S_7^{M*} \end{bmatrix}$$

The entries of C_p are computed using (13). As a result, obtain C_1^T as:

$$\begin{bmatrix} s_1^1 + \bar{s}_3^1 + \hat{s}_5^1 + \check{s}_7^1 & s_2^1 + \bar{s}_4^1 + \hat{s}_6^1 + \check{s}_8^1 \\ -s_2^{1*} - \bar{s}_4^{1*} - \hat{s}_6^{1*} - \check{s}_8^{1*} & s_1^{1*} + \bar{s}_3^{1*} + \hat{s}_5^{1*} + \check{s}_7^{1*} \\ s_1^1 - \bar{s}_3^1 + \hat{s}_5^1 - \check{s}_7^1 & s_2^1 - \bar{s}_4^1 + \hat{s}_6^1 - \check{s}_8^1 \\ -s_2^{1*} + \bar{s}_4^{1*} - \hat{s}_6^{1*} + \check{s}_8^{1*} & s_1^{1*} - \bar{s}_3^{1*} + \hat{s}_5^{1*} - \check{s}_7^{1*} \\ \vdots & \vdots \\ s_1^M + \bar{s}_3^M + \hat{s}_5^M + \check{s}_7^M & s_2^M + \bar{s}_4^M + \hat{s}_6^M + \check{s}_8^M \\ -s_2^{M*} - \bar{s}_4^{M*} - \hat{s}_6^{M*} - \check{s}_8^{M*} & s_1^{M*} + \bar{s}_3^{M*} + \hat{s}_5^{M*} + \check{s}_7^{M*} \\ s_1^M - \bar{s}_3^M + \hat{s}_5^M - \check{s}_7^M & s_2^M - \bar{s}_4^M + \hat{s}_6^M - \check{s}_8^M \\ -s_2^{M*} + \bar{s}_4^{M*} - \hat{s}_6^{M*} + \check{s}_8^{M*} & s_1^{M*} - \bar{s}_3^{M*} + \hat{s}_5^{M*} - \check{s}_7^{M*} \end{bmatrix}, \quad (15)$$

And C_2^T as:

$$\begin{bmatrix} s_1^1 + \bar{s}_3^1 - \hat{s}_5^1 - \check{s}_7^1 & s_2^1 + \bar{s}_4^1 - \hat{s}_6^1 - \check{s}_8^1 \\ -s_2^{1*} - \bar{s}_4^{1*} + \hat{s}_6^{1*} + \check{s}_8^{1*} & s_1^{1*} + \bar{s}_3^{1*} - \hat{s}_5^{1*} - \check{s}_7^{1*} \\ s_1^1 - \bar{s}_3^1 - \hat{s}_5^1 + \check{s}_7^1 & s_2^1 - \bar{s}_4^1 - \hat{s}_6^1 + \check{s}_8^1 \\ -s_2^{1*} + \bar{s}_4^{1*} + \hat{s}_6^{1*} - \check{s}_8^{1*} & s_1^{1*} - \bar{s}_3^{1*} - \hat{s}_5^{1*} + \check{s}_7^{1*} \\ \vdots & \vdots \\ s_1^M + \bar{s}_3^M - \hat{s}_5^M - \check{s}_7^M & s_2^M + \bar{s}_4^M - \hat{s}_6^M - \check{s}_8^M \\ -s_2^{M*} - \bar{s}_4^{M*} + \hat{s}_6^{M*} + \check{s}_8^{M*} & s_1^{M*} + \bar{s}_3^{M*} - \hat{s}_5^{M*} - \check{s}_7^{M*} \\ s_1^M - \bar{s}_3^M - \hat{s}_5^M + \check{s}_7^M & s_2^M - \bar{s}_4^M - \hat{s}_6^M + \check{s}_8^M \\ -s_2^{M*} + \bar{s}_4^{M*} + \hat{s}_6^{M*} - \check{s}_8^{M*} & s_1^{M*} - \bar{s}_3^{M*} - \hat{s}_5^{M*} + \check{s}_7^{M*} \end{bmatrix}, \quad (16)$$

Note that the code provides one symbol per OFDM per radiation.

5. RESULTS

The simulation results will present in this section. In the proposed work, the author assumed that he have these properties: $P = 2$, $M_t = 2$, $M_r = 1$ and $N_c = 128$.

In his simulations, he assumed that the channel is perfect, and he chose a BPSK constellation, 1 bit/sec/Hz spectral efficiency, where ignored the cyclic prefix (overhead). Fig. 2 shows the results at delay spread of $\tau = 5\mu s$.

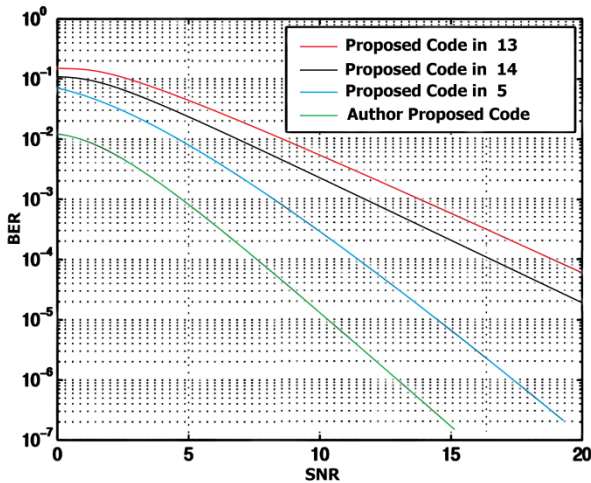


Fig. 2. BER vs SNR for the Proposed System.

The performance improving compared to [13], [14] and [5] is shown in the figure above.

6. CONCLUSION

The author implemented a NOVEL MIMO - OFDM technique for improving the wireless communications systems performance based on SF - BC.

Where, the designed code is based on the principle of QOC using the techniques of the reconfigurable antennas.

And he provided simulation results using MATLAB program to prove the NOVELTY of his code with comparison with the other SF codes.

Where the implemented code produces additional higher coding gains and diversity (Low BER at Low SNR) compared with other technique.

7. ACKNOWLEDGMENT

The author would like to thank THE GOD, the almighty, who gave him the reconcile to complete his research. Only due to THE GOD blessing, he could finish it successfully.

8. REFERENCES

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