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DETECTION OF SC-SFBC SIGNALS SENT ABOVE A FREQUENCY-SELECTIVE WIRELESS NETWORK

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The detection of single carrier space frequency block coded (SC-SFBC) in frequency selective wireless is the theme of this paper. Channels with numerous inputs and outputs have ISI, which is caused by the channel's frequency selectivity. An ISI arises in a single carrier SFBC system when the 'quasi-static' fading postulation is as a result of the wireless Multiple Input, Multiple Output channel's frequency selectivity. In this study, we analyze and offer a performance evaluation for interference revocation receivers that reduce ISI in frequency-selective MIMO channels by adopting space frequency block coded single carrier frequency domain equalization (SFBC SC-FDE) (SFBC SC-FDE) (SFBC SC-FDE).

Keywords: Interference; SFBC; and Equalization; frequency domain (FDE).

1. INTRODUCTION

In single-carrier communication systems, equalisation can be completed in the frequency domain or the time domain, which has been researched in [1]. SC-FDE and OFDM have similar performance and structure. It has been shown that it is a feasible alternative to broadband wireless networks [2,3]. In comparison to OFDM, SC-FDE has a lower power ratio between the peak and the average. Consequently, the power amplifier's necessary dynamic range is reduced, and the battery life is longer than with OFDM [2,4]. While the nonlinear distortion and carrier synchronisation issues that come with OFDM are inconvenient, STC is a wireless multiple-input, multiple-output (MIMO) communication method that adds spatial variation to data sent via many antennas by introducing spatial and temporal correlations [5]. Alamouti was the first to suggest a simple and effective diversity strategy based on two transmit antennas.

Due to its numerous appealing qualities, the STBC technique has been suggested for various radio broadcast applications [5]. With two transmit antennas and a full transmission rate, it delivers complete spatial variety for any signal constellation. Second, at the transmitter, no channel-side information is necessary. The STBC system is excellent for gradually fluctuating channels since the channel is intended to stay steady for two successive symbol periods [5,1,6]. The SFBC SC-FDE system was created to combat the effects of a high-speed mobile environment that causes rapid fading [7]. As a consequence, a practical solution to the problem of fast fading distortion in a frequency indiscriminate fading mobile environment has been developed [4]. In

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extremely frequency-selective SFBC channels, violation of the 'quasi-static' (i.e, fading stays constant across one block, which is only achievable in a slow-fading environment) assumption in the dimension of frequency leads to a violation of the In a SFBC system, the loss of the "quasi-static" premise in a highly frequency-selective environment causes ISI in the dimension of frequency [7] created the SFBC SC-FDE system and published it in the literature. They do not, however, take into account the loss of the "quasi-static" assumption in wide-delayed spread channels. In SFBC, eliminating ISI improves SC-FDE performance (since the "quasi-static" assumption has been removed). Linear equalizers such as MMSE and zero-forcing techniques may be utilised [8]; this requires matrix inversion, which can be reduced in complexity if suggested interference canceller receivers are used. As a result, we suggest an interference canceller receiver technique in this study to limit the impact of ISI in SFBC SC-FDE.

The increasing demand for wireless multimedia and interactive interner services is fulfilling intensive research efforts on high speed data transmission. A major design challenge for high speed broadband application is the time-dispersive nature of the rerrestrial radio channel [9].

2. SFBC SC-FDE SYSTEM

2.1 Transmitted Signal Model

There are two antennas for transmission and one antenna for reception used in the single carrier system. Because the transmit categorisation of the SC system remains popular the time domain, we can't apply the SFBC method directly to it. The FFT and inverse Fourier transform IFFT blocks are displayed in Fig. 1 and give the SFBC its orthogonal structure. The nth signal in the broadcast block from the jth antenna is referred to as Using the IFFT, the first antenna's transmitted signal may be expressed as

$$x1(n) = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X_1(k) W_N^{-mn}$$
$$= \frac{1}{\sqrt{N}} \sum_{v=0}^{(N/2)-1} (X_1(2v) + W_N^{-n} X1(2v + 1)) W_{(\frac{N}{2})}^{-mv}$$
$$= \frac{1}{\sqrt{2}} \sum_{v=0}^{(N/2)-1} (x^e(n) + W_N^{-n} x^0(n)), n = 0, 1, \ldots N-1 \qquad (1)$$

Where $x^o(n)$ and $x^e(n)$, $n = 0, 1 \ldots\ldots, N-1$ are symbols that have been passed

$$x^e(n) = \sqrt{\frac{2}{N}} \sum_{v=0}^{(\frac{N}{2})-1} X1(2v) W_{(\frac{N}{2})}^{-nv}$$
$$x^0(n) = \sqrt{\frac{2}{N}} \sum_{v=0}^{(\frac{N}{2})-1} X1(2v+1) W_{(\frac{N}{2})}^{-nv} \qquad (2)$$

Since $x^o(n)$ and $x^e(n)$ may be described as being episodic in n with epoch $N/2$, We have the ability to write again as $x^o((n))_{(N/2)}$ and $x^e((n))_{(N/2)}$.

The IFFT scaling factor was used in equations (1) and (2) such that the normalisation power sent from each sending antenna equals unity. Similarly, transmitted signal $x_2(n)$ SFBC and the DFT property are used, the second antenna may be calculated [10].

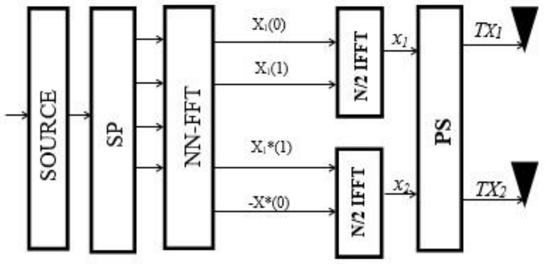

Fig. 1(a). Scheme of transmission

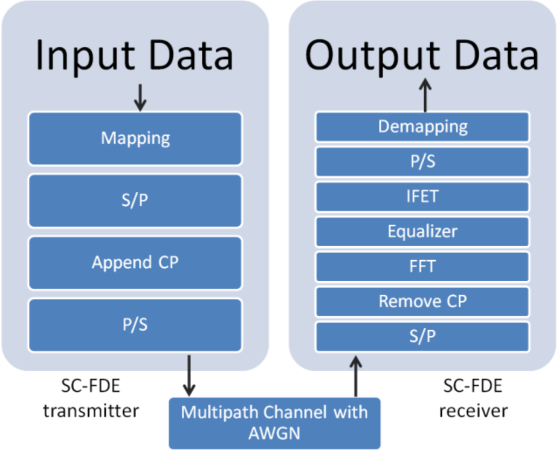

Fig. 1(b). Block diagram of SFBC SC-FDE system

Odd and even group symbols are demultiplexed as follows:

$$x^0(z) = x(2z+1), x^e(z) = x(2z), x = 0, 1, \ldots, \frac{N}{2} - 1 \qquad (3)$$

$$x_2(n) = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X_2(k) W_N^{-mn}$$

$$= \frac{1}{\sqrt{N}} \sum_{v=0}^{(\frac{N}{2})-1} (-X_1^*(2v+1) \\ + W_N^{-n} X_1^*(2v) W_{N/2}^{-nv}$$

$$= \frac{1}{\sqrt{2N}} (-x^{0^*}(n) + W_N^{-n} x^{e^*}(n)) \qquad (4)$$

To lower the result of IBI, each block of fixed Length is prefixed at the top with a length-Np cyclic prefix, and channel matrices convert circulant. Fig. 1(b) shows SFBC SC-FDE system block diagram.

2.2 Model of the Received Signal

We presume that the receiver's channel estimate is good. The transmitted signal $\mathbf{x}_j : \left\{ x_j(n) \right\}_{n=0}^{N-1}$, where j is the received block and 1&2 is the received block $\mathbf{y} : \{y(n)\}_{n=0}^{N-1}$ (after eliminating the first Np symbols received that conform to the cyclic prefix) is

$$\mathbf{y} = \mathbf{h}_1 \mathbf{x}_1 + \mathbf{h}_2 \mathbf{x}_2 + \mathbf{n} \qquad (5)$$

The N x N first and second transmit antennas' right circulant channel matrices respectively, are hi, i=1, 2; the first column represents the CIR and the second column representing the AWGN Gaussian noise symbols with length N x 1. Multiplying the length N x N twiddle matrix W by the DFT of equation (5),

$$\mathbf{Y} = \mathbf{W}\mathbf{h}_1\mathbf{W}^\mathbf{H}\mathbf{X}_1 + \mathbf{W}\mathbf{h}_2\mathbf{W}^\mathbf{H}\mathbf{X}_2 + \mathbf{N}',$$
$$\mathbf{N}' \triangleq \mathbf{W}\mathbf{n} \qquad (6)$$

where $(\bullet)^H$ signifies a conjugate transposition with a complex conjugate. Let $\boldsymbol{\rho}_i = \mathbf{W}\mathbf{h}_i\mathbf{W}^\mathbf{H}$, i=1 & 2.The DFT of the channel impulse rejoinder is represented by the diagonal element of the diagonal matrix. Equation (6) As follows, It may be divided into two frequency components: even and odd:

$$Y(2k) = \rho_1(2k)X_1(2k) - \rho_2(2k)X_1^*(2k+1) \\ + N'(2k)$$
$$Y^*(2k+1) = \rho_1^*(2k+1)X_1^*(2k+1) \\ - \rho_2^*(2k+1)X_1^*(2k+1) \\ + N'(2k+1),$$
$$k = 0,1,\ldots,\frac{N}{2} - 1 \qquad (7)$$

The coldness amid the jth transmitter and the receiver, where $\rho_j(k)$ indicates the CFR of the k th subcarrier.

2.2.1 SFBC SC-FDE detection for frequency flat condition

There is no ISI in the situation of frequency flatness. We shoulder that the channel frequency retort is continuous during two symbol intervals in the STBC system [5]. Likewise, in the SFBC system, the channel frequency response of two consecutive subcarriers is identical i.e. $\rho_1(2k) \approx \rho_1(2k+1)$ and $\rho_2(2k) \approx \rho_2(2k+1)$ for large N [6]. Then, in matrix form, equation (7) may be represented as

$$\mathbf{Y}_k \triangleq \begin{pmatrix} Y(2k) \\ Y(2k+1) \end{pmatrix}$$
$$= \begin{pmatrix} \rho_1(2k) & -\rho(2k) \\ \rho_2^*(2k) & \rho_1^*(2k) \end{pmatrix} \begin{pmatrix} X_1(2k) \\ X_1^*(2k+1) \end{pmatrix} + \begin{pmatrix} N'(2k) \\ N'(2k+1) \end{pmatrix} \qquad (8)$$
$$= \boldsymbol{\rho}_k \mathbf{X}_k + \mathbf{N}_k^{'}$$

An estimation of $\mathbf{Y}_k$ using Minimum Mean Squared Error equalizers [11] may be acquired in the following formats:

$$\hat{\mathbf{Y}}_k \triangleq \boldsymbol{\rho}_k^H \mathbf{Y}_k$$
$$= \begin{pmatrix} \hat{\rho}_k & 0 \\ 0 & \hat{\rho}_k \end{pmatrix} \mathbf{X}_k + \hat{\mathbf{N}}_k^{'}$$

where $\hat{\rho}_k = \left|\rho_1(2k)\right|^2 + \left|\rho_2(2k)\right|^2$, $\hat{\mathbf{N}}_k^{'} = \boldsymbol{\rho}_k^H \mathbf{N}_k^{'}$

We can see that $\boldsymbol{\rho}_k^H \boldsymbol{\rho}_k$ is a diagonal matrix, hence there will be no inter-symbol interference owing to the elimination of the 'quasi-static' assumption (ISI). Obtain an approximated symbol as,

$$\hat{\mathbf{X}}_k \triangleq (\boldsymbol{\rho}_k^H \boldsymbol{\rho}_k + \frac{1}{SNR}\mathbf{I}_2)^{-1} \hat{\mathbf{Y}}_k = \begin{pmatrix} \hat{X}^e(k) \\ \hat{X}^o(k) \end{pmatrix}$$
$$= \begin{pmatrix} \hat{X}_1(2k) \\ \hat{X}_1^*(2k+1) \end{pmatrix} \qquad (9)$$

2.2.2 Receiver with an interference canceller that has been proposed

For the SFBC SC-FDE, this part has an interference canceller detector. The suggested receiver calculates and lowers the ISI produced by the 'quasi-static' assumption being lost i.e. $\rho_1(2k) \neq \rho_1(2k+1)$ and $\rho_2(2k) \neq \rho_2(2k+1)$ Then, in matrix form, equation (7) can be written as

$$\begin{aligned}\mathbf{Y}_{k,LQS} &\triangleq \begin{pmatrix} Y(2k) \\ Y(2k+1) \end{pmatrix} \\ &= \begin{pmatrix} \rho_1(2k) & -\rho(2k) \\ \rho_2^*(2k+1) & \rho_1^*(2k+1) \end{pmatrix} \begin{pmatrix} X_1(2k) \\ X_1^*(2k+1) \end{pmatrix} + \begin{pmatrix} N'(2k) \\ N'(2k+1) \end{pmatrix} \\ &= \boldsymbol{\rho}_{k,LQS} \mathbf{X}_{k,LQS} + \mathbf{N}'_{k,LQS}\end{aligned} \tag{10}$$

where $\mathbf{Y}_{k,LQS}$ reflect the received signal if the 'quasi-static' assumption is broken. First, we simulate ISI as a result of the loss of the 'quasi-static' assumption. We split $\boldsymbol{\rho}_{k,LQS}$ in to two parts $\boldsymbol{\rho}_{nisi}$ and $\boldsymbol{\rho}_{isi}$, so that

$$\boldsymbol{\rho}_{k,LQS} = \boldsymbol{\rho}_{nisi} + \boldsymbol{\rho}_{isi} \tag{11}$$

where

$$\boldsymbol{\rho}_{nisi} = \begin{pmatrix} \rho_1(2k) & -\rho(2k) \\ \rho_2^*(2k) & \rho_1^*(2k) \end{pmatrix}, \tag{12}$$

and

$$\boldsymbol{\rho}_{isi} = \begin{pmatrix} 0 & 0 \\ \Delta\rho_2(2k) & \Delta\rho_1(2k) \end{pmatrix}. \tag{13}$$

where $\Delta\rho_1(2k) = \rho_1^*(2k+1) - \rho_1^*(2k)$ and $\Delta\rho_2(2k) = \rho_2^*(2k+1) - \rho_2^*(2k)$

Based on equation (11), (12) and (13), we can write (10) as

$$\mathbf{Y}_{k,LQS} = \boldsymbol{\rho}_{nisi}\mathbf{X}_k + \underbrace{\boldsymbol{\rho}_{isi}\mathbf{X}_k}_{\text{Perception of 'quasi-static'}} + \mathbf{N}'_k$$

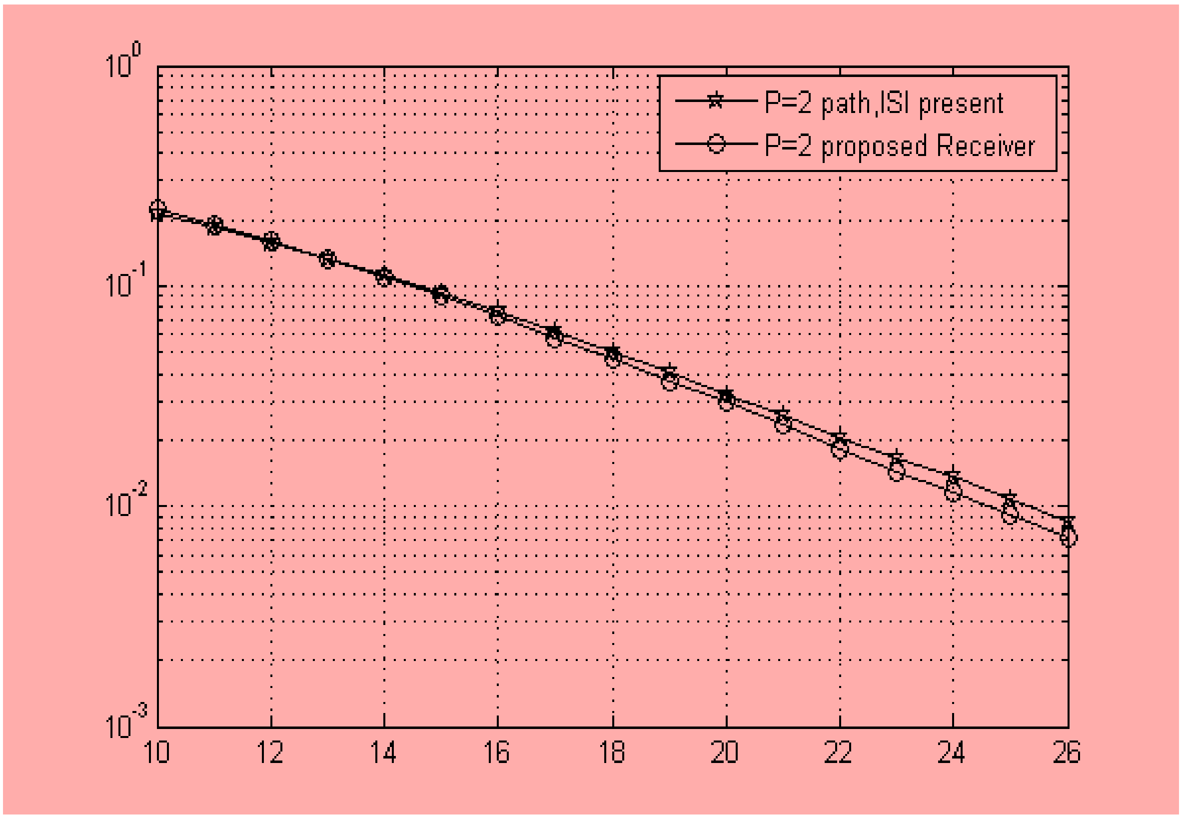

Fig. 2. Displays the SFBC SC-Bit SFBC's Error Rate performance for frequency-specific Rayleigh's fade with N=64 QPSK modulation and P = 2 pathways

A rough estimate of $\mathbf{Y}_{k,LQS}$ may be derived as follows:

$$\hat{\mathbf{Y}}_{k,LQS} \triangleq \boldsymbol{\rho}_{nisi}^{H}\mathbf{Y}_{k,LQS} = \underbrace{\begin{pmatrix}\hat{\rho}_k & 0\\ 0 & \hat{\rho}_k\end{pmatrix}\mathbf{X}_k}_{\text{Required signal}} + \underbrace{\boldsymbol{\rho}_{nisi}^{H}\boldsymbol{\rho}_{isi}\mathbf{X}_k}_{\text{ISI}} + \underbrace{\boldsymbol{\rho}_{nisi}^{H}\hat{\mathbf{N}}'_k}_{\text{Noise}} \tag{14}$$

where $\hat{\rho}_k = \left|\rho_1(2k)\right|^2 + \left|\rho_2(2k)\right|^2$

As can be seen, equation (14) contains information on the needed signal, ISI, and noise in the estimate $\hat{\mathbf{Y}}_{k,LQS}$. The proposed interference estimation and cancellation receiver method is described below, depending on the received signal's model in equation (14) and understanding of the matrices $\boldsymbol{\rho}_{nisi}$ and $\boldsymbol{\rho}_{isi}$ formation.

(1) Estimate $\hat{\mathbf{X}}_k$ the from equation (14) for every SFBC k, disregarding ISI.

(2) Estimate the ISI from (14) (i.e, 2nd term in equation (14)) for each SFBC.

(3) Cancel the ISI that was calculated in step 2 from $\hat{\mathbf{Y}}_{k,LQS}$

We summarized the interference cancellation method for the L stage based on the prior discussion.

At the first stage: set L=1.

Assess

$$\hat{\mathbf{Y}}_k^{(L)} \triangleq \boldsymbol{\rho}_{nisi}^{H}\mathbf{Y}_{k,LQS}$$

Repeat:

Estimate

$$\hat{\mathbf{X}}_k^{(L)} \triangleq (\boldsymbol{\rho}_{nisi}^{H}\boldsymbol{\rho}_{nisi} + \frac{1}{SNR}\mathbf{I}_2)^{-1}\hat{\mathbf{Y}}_k^{(L)}$$

Abandon ISI

$$\hat{\mathbf{Y}}_k^{(L+1)} = \hat{\mathbf{Y}}_k^{(1)} - \boldsymbol{\rho}_{nisi}^{H}\boldsymbol{\rho}_{isi}\hat{\mathbf{X}}_k^{(L)}$$

$$L = L + 1$$

proceed to Repeat.

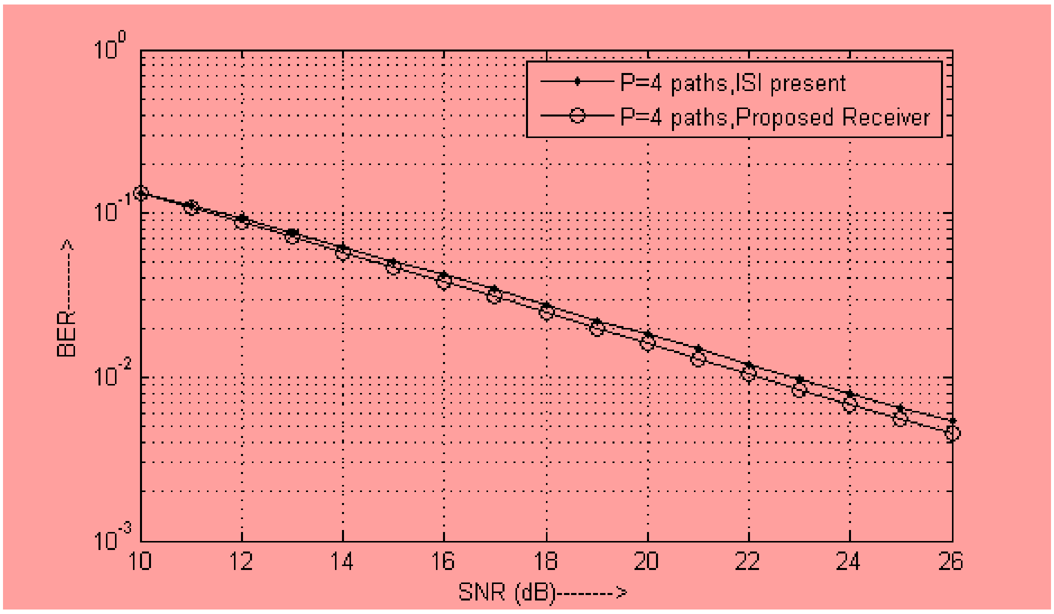

Fig. 3. Rayleigh fading using frequency-selective QPSK modulation and P = 4 pathways, BER performance of the SFBC SC-FDE was measured

It should be noticed that $\boldsymbol{\rho}_{nisi}^{H}\boldsymbol{\rho}_{nisi}$ is a diagonal matrix, which makes inversion straightforward. Perfect channel estimation is necessary in this approach, which may be obtained using, for example, the algorithm described in [12].

3. SIMULATION RESULTS

The BER of the SFBC SC-FDE for two communicate antennas and unique reception antenna structure was calculated using simulation software MATLAB. At the receiver, the CSI is believed to be known [9]. We employed N = 64 symbols with QPSK modulation, fc = 5 GHz, and a thoroughgoing Doppler shift of 200 Hz as system characteristics. Figs. 2 and 3 demonstrate this. For the SFBC SC-FDE, in a frequency-selective Rayleigh disappearing channel through equitable paths P=2 and P=4 we demonstrate the BER performance of the suggested interference canceller receiver [13]. Due to the small channel delay spread, the induced ISI is negligible for P=2, and so there is no substantial performance increase. However, because of the huge channel delay spread, the induced ISI for P=4 is considerable [14], and the suggested receiver provides a significant performance boost (e.g, Signal to Noise Ratio 10 dB-16 dB).

4. CONCLUSION

In the SFBC Single Carrier-FDE system, we presented an interference canceller algorithm for frequency-selectivity induced ISI. We estimate the ISI and then cancel it in this algorithm. To reduce ISI-induced error-floors, this method may be repeated in several phases. According to our simulation findings, the suggested detector mitigates the influence of ISI in a frequency-selective channel. The proposed interference canceller receiver algorithm can also be useful to space time frequency coded (STFC) transmissions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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