(JZS) Journal of Zankoy Sulaimani,2010,13(1) Part A ,(49-58)

گۆڤاری زانکۆی سلێمانی , ۲۰۱۰, بەرگ۱۳(۱) بەشی A

New Trend of Space-Frequency Block Code-OFDM

Thuraya M. Al-Qaradaghi*, Refat Talib Hussein**
* College of Engineering University of Salahideen/Erbil
**Electrical Engineering Dept. University of Technology

Abstract:

To avoid the problem of fast channel variations in time, the symbols of an orthogonal design can be transmitted on neighboring subcarriers of the same Orthogonal Frequency Division Multiplexing (OFDM) symbol rather than on the same subcarrier of the subsequent OFDM symbols. This also reduces the transmission delay. Space-Frequency Block Codes (SFBC) avoids the problem of fast time variations. A new trend of SFBC introduced and examined for flat and frequency-selective channels over various values of Doppler frequencies and various type of modulation (QPSK, 8-PSK, 16-QAM and 32-QAM). Alamouti code was applied to a block of the odd and even elements instead of one symbol. The performance comparisons of bit error probability for the conventional SFBC-OFDM and the proposed one have been presented. As a result, it can be concluded that the proposed structure achieves much lower bit error rates. MATLAB version 7.4 had been used as a simulation tool.

Keywords- STC, SFBC, OFDM.

Introduction

The wireless channel mainly suffers from time-varying fading due to multipath propagation and destructive superposition of signal received over different paths, which make it hard for the receiver to reliably determine the transmitted signal unless some less attenuated replica of the signal are provided to the receiver. Transmitting the replica of the signal is called diversity. A widely applied technique to reduce the effects of multipath fading is antenna diversity [1].

Space-Time Codes (STC) were first introduced by Tarokh et al. from AT&T research Labs. in 1998 as a novel means of providing transmit diversity for multiple antenna fading channel. They generalized the transmission scheme to an arbitrary number of transmit antennas, which can achieve the full diversity promised by the transmit and receive antennas [2,3].

Alamouti (1998) proposed Initial and simple examples of implementation of space-time coding, two-branch transmit diversity scheme, using two transmit antennas and one receive antenna. STBC was first proposed by Alamouti for flat fading channels. Alamouti introduced a code named Alamouti code which shown below [4]:

$$\begin{bmatrix} X(i) \\ X(i+1) \end{bmatrix} = \begin{bmatrix} X(i) & -X^*(i+1) \\ X(i+1) & X^*(i) \end{bmatrix} \begin{matrix} \rightarrow \textit{time} \\ \downarrow \textit{space} \end{matrix}$$

Orthogonal frequency-division multiplexing (OFDM) is an excellent technique to reduce the effect of frequency-selective fading by dividing the transmission bandwidth into many narrow-band subcarriers, each of which exhibits an approximately flat fading[5,6].

Naderi and Pourmina [7] investigated the suitability and performance of space-frequency block codes under UWB channel and for a Multi-Band Orthogonal Frequency Division Multiplexing (MBOFDM) System, and concluded that space-frequency block codes provide

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* E-mail : Thorayam2001@yahoo.com ** E-mail :zubid1flower@yahoo.com

performance improvement for MB-OFDM system even in the worst conditions of UWB channel.

However, for the wireless mobile environment, two main impairments still dominate the system performance; firstly, the interblock interference (IBI), caused by the temporal channel dispersion, and secondly, the intercarrier interference (ICI), resulting from the temporal channel variation. Fortunately, the IBI can be eliminated completely with the aid of sufficient cyclic prefix (CP). Similarly, there also exit some schemes to mitigate the ICI, yet the receiver complexity increases dramatically due to the need for more accurate channel estimation for interference cancellation.

The traditional approach to mitigate fading effects is to simply allow for deep fades by increasing the transmit power. However, this simple approach leads to a majority of the time transmitting multiple times the actual required power for reliable communications, therefore causing high power consumption and considerable user interference.

Therefore, for the wireless mobile OFDM systems, transmit diversity that increases little receiver complexity can be an efficient option to provide not only the mitigation of the ICI, but also the robustness to deep fading [8].

A more recent and successful scheme to overcome the effects of the signal fading is that of exploiting channel diversity. The principle is for the receiver to obtain several independent copies of the signal of the interest transmitted over independently fading channels, thus the probability that the entire signal components will fade simultaneously is considerably reduced. Several different schemes for obtaining several replicas of the signal have been proposed:

Time Diversity: Time diversity repeatedly transmits information at time spacing that exceed the coherent time of the channel, where the coherent time is the minimum time separation between independent channel fades.

Frequency Diversity: Frequency diversity simply transmits information on more than one carrier frequency. Provided the frequencies are separated by more than the coherent bandwidth of the channel they will not experience the same fades. The coherent bandwidth of the channel is the minimum frequency separation between independent fades and is inversely proportional to the delay spread of the channel.

Polarization Diversity: With the increase in mobile services, vertically polarized whip antennas are becoming obsolete due to problems with hand-tilting of the receiver. This recent change has increased interest in utilizing polarization diversity at the base station. Polarization diversity consists of transmitting information over two orthogonally polarized antennas.

Space Diversity: One of the oldest techniques and with a recent resurgence in interest, space diversity is a strong contender for many wireless communication systems. By using spatially separated multiple antennas we can reduce the probability of losing the signal by combining the antenna signals in order to increase the received average power [9].

Wireless systems of communication have recently turned to a strategy known as Multiple Input Multiple Output (MIMO) to improve the quality (bit-error rate) and data rate (bits/sec). This advantage can increase the quality of service and revenues of the operator. This is done by using multiple transmit and receive antennas, as well as appropriate coding techniques. They take advantage of spatial and temporal diversity to combat the random fading induced by multi-path propagation of the signal and maximize efficient use of bandwidth. There is also a fundamental gain in transmitting data over a matrix rather than vector channel. Transmission of data over MIMO channels has traditionally focused on data rate maximization or diversity maximization [10]. Space-Time coding codes information across antennas (space) and time.

Space-Frequency Block Code-OFDM (SFBC-OFDM):

To avoid the problem of fast channel variations in time, the symbols of an orthogonal design can be transmitted on neighboring subcarriers of the same OFDM symbol rather than on the same subcarrier of the subsequent OFDM symbols. This also reduces the transmission delay. However, the channel needs to be about constant over P neighboring subcarriers. This is true in channels with low frequency-selectivity or can be accomplished by using a large number of subcarriers in order to make the subcarrier spacing very narrow. Space-Frequency Block Codes avoid the problem of fast time variations. However, the performance will degrade in heavily frequency-selective channels where the assumption of constant channel coefficients over a space-frequency block code matrix is not justified. Particularly, this is a problem for a system having more than two-transmit antennas [11,12].

Space-frequency block codes require that the coherence bandwidth B_c meets:

$$B_c > \boldsymbol{P}/T_{s,OFDM} \,,$$

where $\boldsymbol{P}$ is the number of rows of the orthogonal design, and $1/T_{s,OFDM}$ is the subcarrier spacing.

The transmitter block diagram of conventional 2x2SFBC-OFDM shown in Figure(1).

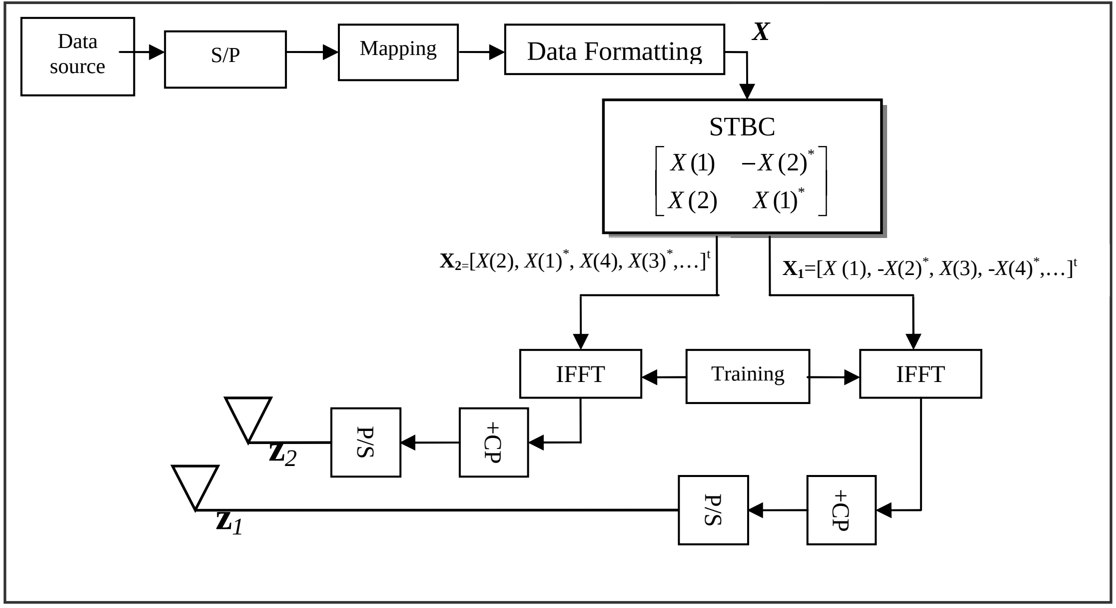


Figure (1): 2x2 SFBC-OFDM Transmitter Block Diagram.

Space-frequency encoder codes each data vector **X**(*i*) (depending on Alamouti code),

$$\mathbf{X}(i)=\left[\,X\,(i,0)\;\;X\,(i,1)\cdots X\,(i,N-2)\;\;X\,(i,N-1)\right]^t,$$

into two vectors $\mathbf{X}_1$(n) and $\mathbf{X}_2$(n) as:

$$\mathbf{X}_1(i)=\left[X(i,0)\;\;-X^*(i,1)\cdots X(i,N-2)\;\;-X^*(i,N-1)\right]^t$$

$$\mathbf{X}_2(i)=\left[X(i,1)\;\;\;X^*(i,0)\cdots X(i,N-1)\;\;\;X^*(i,N-2)\right]^t,$$

where *N* is the number of subcarriers, and * denotes complex conjugate.

SFBC-OFDM is more sensitive to channel gain variation over frequency band [13].

At the receiver:

The signals at the first receiver (Rx_1) are:

$$y_{11}=h_{11}x_1+h_{12}x_2+n_{11}\,\text{.........}\;(1)$$

$$y_{12}=-h_{11}x_2^*+h_{12}x_1^*+n_{12}\,\text{.......}\;(2)$$

While the signals at the second receiver (Rx_2) are:

$$y_{21}=h_{21}x_1+h_{22}x_2+n_{21}\,\text{.........}(3)$$

$$y_{22}=-h_{21}x_2^*+h_{22}x_1^*+n_{22}\,\text{.......}\;(4)$$

Where h_{11}, h_{12}, h_{21} and h_{22} are the channel coefficients.

At the combiner, the received signals are combined to extract the transmitted signals x_1 and x_2 from the received signals y_{11}, y_{12}, y_{21}, and y_{22} as shown below:

$$\tilde{x}_1=h_{11}^*y_{11}+h_{12}y_{12}^*+h_{21}^*y_{21}+h_{22}y_{22}^*\ldots(5)$$

$$\tilde{x}_2=h_{12}^*y_{11}-h_{11}y_{12}^*+h_{22}^*y_{21}-h_{21}y_{22}^*\ldots..(6)$$

Finally, equation (5) and (6) has been simplified to:

$$\tilde{x}_1=(|h_{11}|^2+|h_{12}|^2+|h_{21}|^2+|h_{22}|^2)x_1+h_{11}n_{11}+h_{12}n_{12}^*+h_{21}^*n_{21}+h_{22}n_{22}^*$$

$$\tilde{x}_2=(|h_{11}|^2+|h_{12}|^2+|h_{21}|^2+|h_{22}|^2)x_2+h_{12}n_{11}-h_{11}n_{12}^*+h_{22}^*n_{21}-h_{21}n_{22}^*$$

At last, x_1 and x_2 are derived and passed to a maximum likelihood detector [14, 15, 16, 17].

The Proposed SFBC-OFDM:

The transmitter and receiver block diagram of the proposed SFBC-OFDM are shown in Figures (2) and (3). Two transmit and received antennas were used.

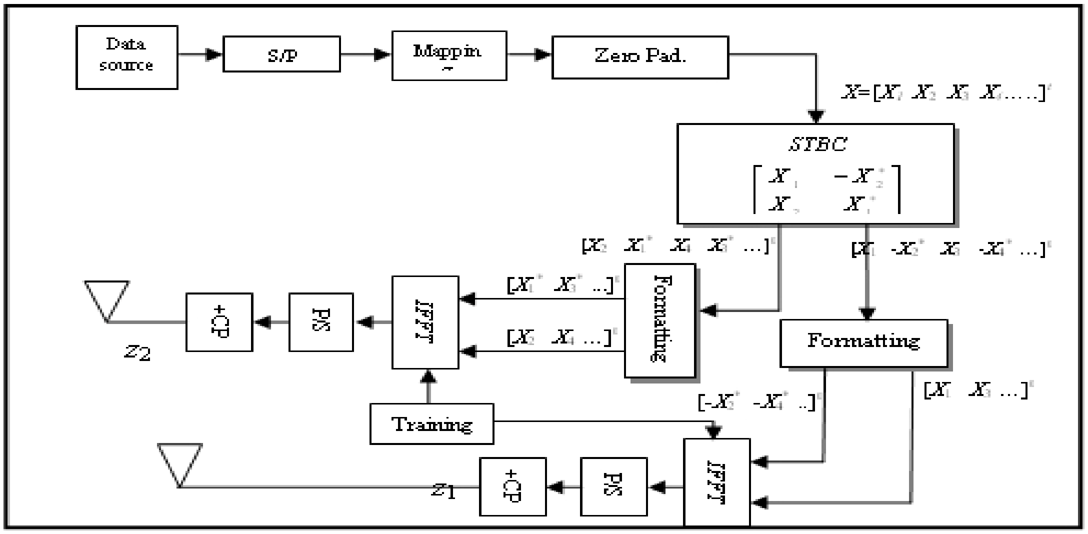
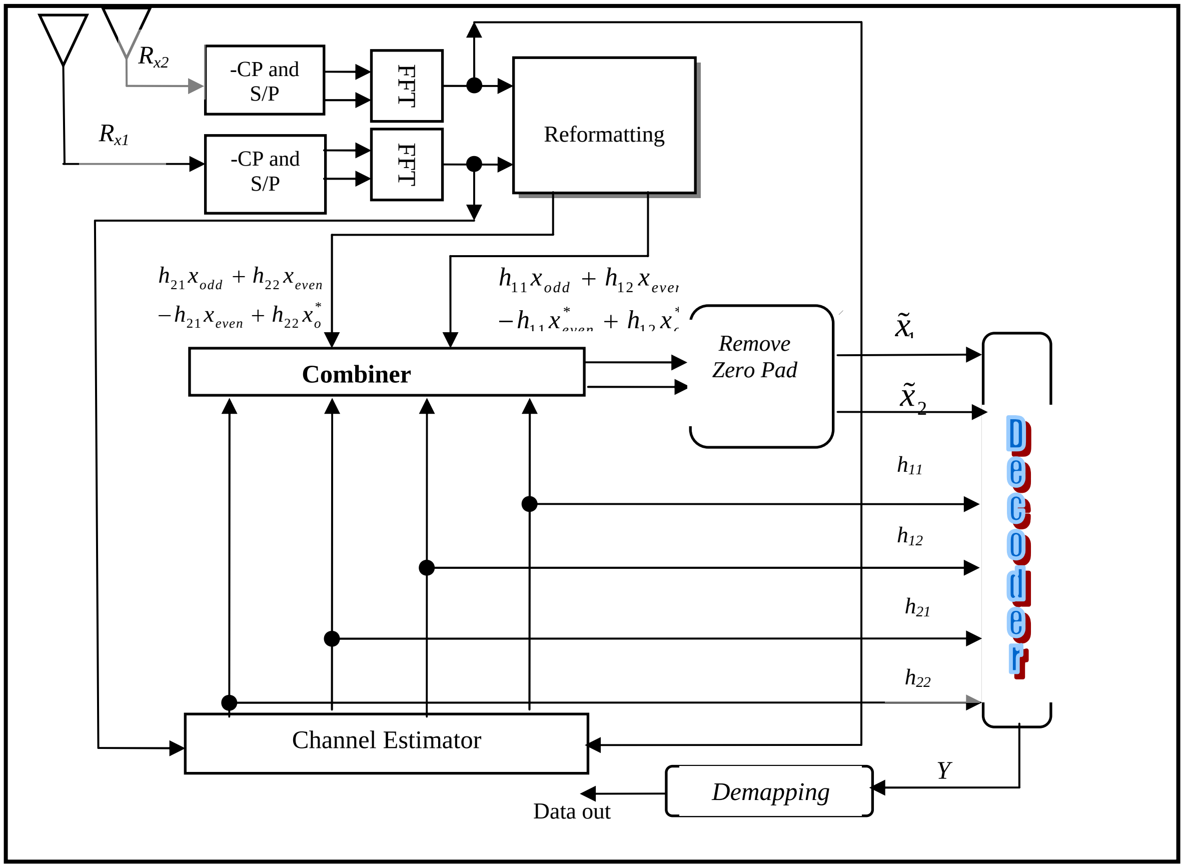


Figure (2): Proposed 2x2SFBC-OFDM Transmitter Block Diagram.



Figure(3): 2x2 SFBC-OFDM receiver.

At the transmitter;

In this system after mapping and zero padding the data stream, the block symbols which indicated as ($\boldsymbol{X} = [X_1, X_2, \ldots, X_N]^t$) are space-time block coded.

The STBC outputs are:

$\boldsymbol{X_1}=[X_1, -X_2^*, X_3, -X_4^*,\ldots,X_{N-1}, -X_N^*]^t$, and

$\boldsymbol{X_2}=[X_2, X_1^*, X_4, X_3^*,\ldots,X_N, X_{N-1}^*]^t$.

The idea of the proposed SFBC is :

$\boldsymbol{X_1}$ is formatted by separating the odd and the even elements to produce two blocks as below:

$[X_1, X_3,\ldots, X_{N-1}]^t$, and

$[-X_2^*, -X_4^*,\ldots, -X_N^*]^t$.

And same formatting done with $\boldsymbol{X_2}$; the two blocks are as shown below:

$[X_2, X_4,\ldots, X_N]^t$, and

$[X_1^*, X_3^*,\ldots, X_{N-1}^*]^t$.

Then each block of these four are passed through ($N/2$)-IFFT. The IFFT (Inverse Fast Fourier Transform) outputs are converted to serial sequences, and then Cyclic Prefix (CP) is added to each parallel-to-serial (P/S) converter output and then $\mathbf{z_1}$ and $\mathbf{z_2}$ are transmitted by antenna-1 and 2 respectively.

$\mathbf{z_1}$ and $\mathbf{z_2}$ sequence are as shown below:

$\mathbf{z_1}=[CP, \textit{Training Sequences}, \mathbf{x}_{odd}, -\mathbf{x}_{even}^*]$

$\mathbf{z_2}=[CP, \textit{Training Sequences}, \mathbf{x}_{even}, \mathbf{x}_{odd}^*]$

The Channel:

Most of the available MIMO techniques are effective in frequency flat scenarios. In this research the simulated system was implemented for three channel states;

a) Single-Path Frequency-Selective Rayleigh Channel with various value of f_d.
b) Multi-Path Frequency-Selective Rayleigh Channel with various value of f_d.

An AWGN (Additive White Gaussian Noise) was added to the received signals with (1- 40 dB) SNR.

At the receiver;

First the CP are removed from the two serial sequence received symbols $\boldsymbol{y_1}$ and $\boldsymbol{y_2}$. They are then passed through serial-to-parallel (S/P) converter. (*N/2*)-FFTs are performed on each S/P output.

Pilot frame (Training) used for channel estimation. The receiver would be informed about this sequence previously, to compensate the channel effects on the signal at the receiver.

At the transmitter two training sequences are generated to be transmitted by each antenna, and inserted in the two branches of the transmitter as below:

$$X_{t1} = [Training\_Sequence^1(n/2), Zeros(n/2)]^t$$

, for transmitter 1

$$X_{t2} = [Zeros(n/2), Training\_Sequence^2(n/2)]^t$$

, for transmitter 2

X_{t1} *and* X_{t2} will be added in the receiver to form single training sequence as shown:

$$X_{t1} + X_{t2} = [Training\_Sequence^1, Training\_Sequence^2]$$

The training part is used to estimate the channels coefficients (h_{11}, h_{12}, h_{21}, and h_{22}).

After reformatting the information part of the received blocks, it passed through the combiner to find the estimated data ($\tilde{x}_1$ and $\tilde{x}_2$).

The systems are implemented for *BPSK* (Binary Phase-Shift Keying), *QPSK* (Quadrature Phase-Shift Keying), *8-PSK,* 16-*QAM* (16-Quadrature Amplitude Modulation), 32-*QAM*, and Doppler frequencies (50, 100, and 150Hz).

$\tilde{x}_1$ and $\tilde{x}_2$ are decoded using Maximum Likelihood Decoder (MLD):
The maximum likelihood decision rule is:
Choose x_i,
iff $(|h_{11}|^2 + |h_{12}|^2 + |h_{21}|^2 + |h_{22}|^2 - 1)|x(i)|^2 + d^2(\tilde{x}, x(i)) \leq (|h_{11}|^2 + |h_{12}|^2 + |h_{21}|^2 + |h_{22}|^2 - 1)|X(k)|^2 + d^2(\tilde{x}, x(k))$, where $i \neq k$.
The decoder output is then demodulated.

Simulation Results:

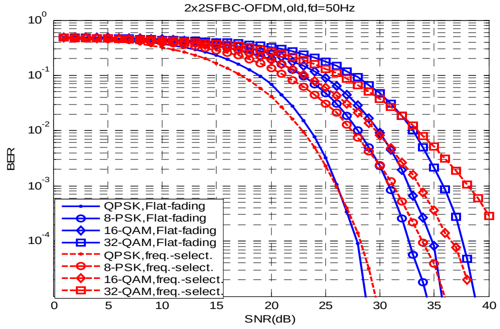
The performances of the proposed systems are evaluated depending on the *BER* versus *S/N* ratio plots. The effects of several parameters of wireless channel on the systems are investigated. Two types of channels, Flat-fading Rayleigh and multi-path frequency-selective are examined. The performance of the conventional 2×2 SFBC-OFDM for Doppler shift frequencies (50, 100, and 150Hz) are shown in figures (4, 5 and 6) respectively, and the performance of the proposed system are shown in figures (7, 8, and 9) respectively. The performance comparison between the two systems for multi-path frequency-selective channel is shown in Table (1). The proposed system gives minimum *S/N* ratio improvement of about 6dB for QPSK modulation at Doppler frequency of 50Hz, and maximum improvement greater than 12dB for modulation type 32-QAM and Doppler frequency equal 150Hz.

Conclusions:

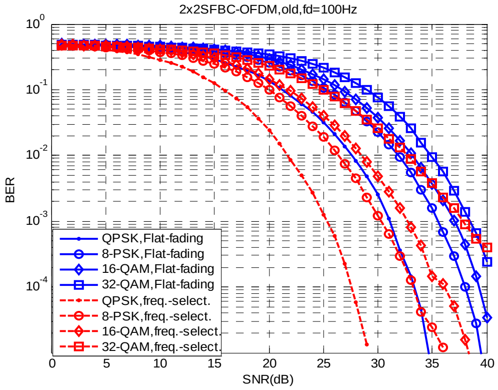
In this paper, SFBC has been evaluated. Encoding and decoding of SFBC is explained; the receiver is able to detect transmitted symbols using simple linear processing. From the results can be concluded that the proposed system is relatively insensitive to Doppler frequency. Therefore, it demonstrates that the SFBC scheme can achieve a significant performance increase for efficient data transmission over slow and fast fading environments.

Table (1): Performance comparison between the conventional and the proposed system for multi-path frequency-selective channel, at *BER*=10^{-5}.

f_d (Hz)	Type of Modulation	Conventional System *S/N* (dB)	Proposed System *S/N* (dB)
50	QPSK	28.5	22.5
	8-PSK	34.5	23
	16-QAM	35.5	23
	32-QAM	38	24.75
100	QPSK	34.5	27.75
	8-PSK	39	27.75
	16-QAM	›40	28.5
	32-QAM	›40	28.5
150	QPSK	34.5	24
	8-PSK	39	26.5
	16-QAM	›40	27
	32-QAM	›40	28



Figure(4): Performance of conventional 2×2SFBC-OFDM system for (fd=50Hz).



Figure(5): Performance of conventional 2×2SFBC-OFDM system for (f_d=100Hz).

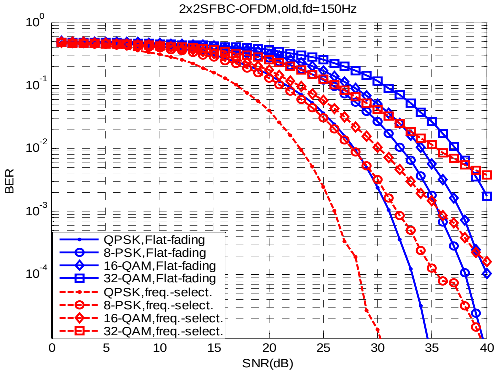
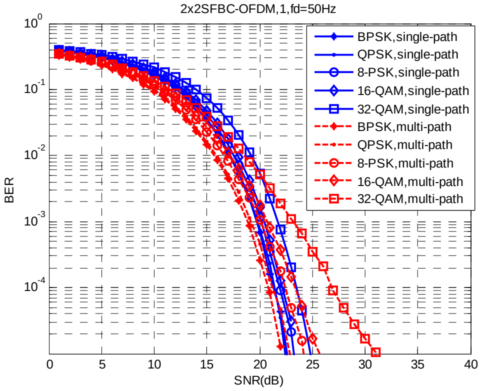


Figure (6): Performance of the 2×2SFBC OFDM system for (f_d=150Hz).



Figure(7):Performance of the 2×2SFBC-OFDM system for (fd=50Hz).

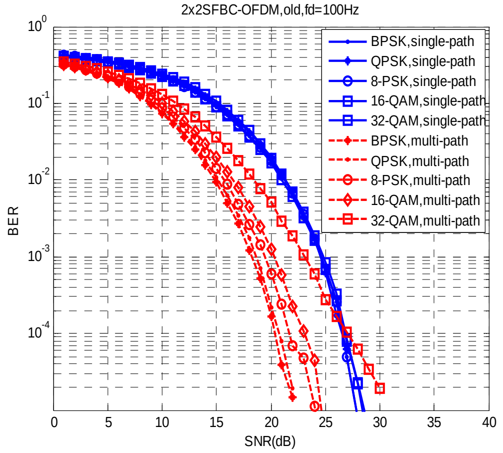


Figure (8): Performance of the 2×2SFBC-OFDM system for (fd=100Hz).

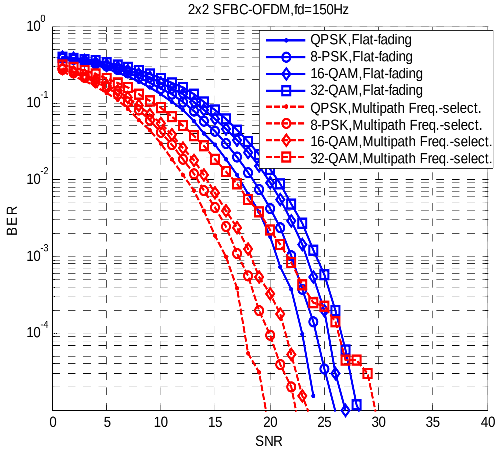


Figure (9): Performance of the 2×2SFBC-OFDM system for (fd=150Hz).

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(JZS) Journal of Zankoy Sulaimani,2010,13(1) Part A

گۆڤاری زانکۆی سلێمانی , ۲۰۱۰, بەرگ۱۳(۱) بەشی A

ئاڕاستەی نوێ بۆ لەرەی بۆشایی بلۆك كۆد (OFDM)

رفعت تالیب حوسین * , ثریا محمود قرەداغی .**

***زانکۆی تەکنەلۆجیا / بەغداد , ** زانکۆی سەلاحەدین / هەولێر .**

پوختە

بۆ دوورکەوتنەوە لە کێشەی تێکڕایی کاتی گۆڕانی کەناڵە خێراکان , نیشانەی دیزاینە ئەستونەکان دەتوانێت بنێرێت لەسەر هەڵگرە لاوەکیە تەنیشتەکانی هەمان (OFDM) لە جیاتی ئەوە لەسەر هەمان نێرەری لاوەکی دوابەدوای نیشانەکانی (OFDM). بەهەمان شێوە دەبێتە هۆی کەمبونەوەی دواکەوتنی ناردن . (SFBC) کێشەی تێکڕایی کاتی گۆڕان دووردەخاتەوە. لەم توێژینەوە سێمبلە تاکەکان جیا ئەکرێتەوە لە جووتەکان وە کۆدی ئەلەموتی بەکاردێنین بۆی . ماتلابی جۆری ٧,٤ بەکارهێنرا وەکو سیمولێشن بۆ ئەم کارە .

إتجاه جديد لنوع التشفير الحيزي الترددي الكتلي لمتعدد الإرسال ذات التردد المتعامد

رفعت طالب حسين* , ثريا محمود قرداغي ** .

*** الجامعة التكنولوجية/بغداد ,** جامعة صلاح الدين/هولير .**

الخلاصة

لتفادي مشكلة التغيرات السريعة لقناة الإتصالات , يمكن ارسال رموز التصميم التعامدي على الحاملة الثانوية الخاصة بالرمز المجاورلنفس متعدد الإرسال ذات التردد المتعامد بدلا" من الحاملة الثانوية الخاصة بالرمز نفسه. أن هذه الطريقة أيضا" تقلل من تأخير الارسال.

هذا البحث يقدم اتجاه جديد لنوع التشفير الحيّزي الترددي الكتلي. المنظومة جربت لأنواع عديدة من التعديل (16-QAM, 8-PSK, QPSK و 32-QAM) **ولقيم مختلفة لتردد الدبلر. نفذت شفرة ألموتي على الكتلة بدلا" من الرمز الواحد. وقد تم فصل الرموز الزوجية عن الفردية لتكوّن كتلتين ومن ثم طبقّت عليها شفرة ألموتي. وكنتيجة تم الحصول على نتائج أفضل. أستخدمت** (MATLAB version 7.4) **كأداة لمحاكاة المنظومة.**

وەرگیراوە لە ۲۰۰۸/٥/٥ دا , و پەسەند کرا لە ۲۰۰۹/۳/٤ دا

Received 5/5/2008 , Accepted 4/3/2009