CHAPTER

Space-Time Coding for FBMC/OQAM

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Rostom Zakaria[*], **Didier Le Ruyet**[*], **Markku Renfors**[†]

Q1 *CEDRIC/LAETITIA Laboratory, Conservatoire National des Arts et Métiers (CNAM), Paris, France*[*]

Q2 *Tampere University of Technology, Tampere, Finland*[†]

CONTENTS

15.1 INTRODUCTION

The introduction of multiple antennas at the transmitter and/or at the receiver provides spatial diversity in the system. This spatial diversity can be exploited using Space Time Block Code (STBC) or Space-Time Trellis Coding (STTC).

The first research works on Space-Time Coding (STC) for FilterBank MultiCarrier with Offset-QAM subcarrier modulation (FBMC/OQAM) were carried out on STTC [1,2]. However, due to the difficult aspect of FBMC/OQAM interference management in STTC, only a single time-delay coding was considered. It was shown that the receiver obtains a sample sequence corresponding to a weighted sum of symbols in time domain. Thus, the data symbols are recovered from the received sequence through the maximum likelihood technique by means of the Viterbi algorithm.

Regarding STBC for FBMC/OQAM, most of the works have considered the well-known Alamouti code. The direct application of Alamouti coding to FBMC/OQAM makes an inherent interference to appear, which cannot be easily removed [3]. The

Orthogonal Waveforms and Filter Banks for Future Communication Systems. DOI: 10.1016/B978-0-12-810384-5.00015-3

difficulty in direct application of the Alamouti scheme to FBMC/OQAM can be conceptually explained by the fact that the Alamouti scheme relies on a complex orthogonality, whereas FBMC/OQAM technique has only a real orthogonality, which cannot lead to the same type of equations [3]. Many works have proposed potential solutions to this drawback, and we will review in this chapter the most significant contributions.

15.2 BASIC ALAMOUTI CODING PRINCIPLE

Alamouti STBC is a famous transmit diversity scheme for two transmit antennas [4]. We consider here mostly the basic scheme with a single receive antenna. Orthogonal sequences of two complex data symbols a_1 and a_2 are transmitted from both transmit antennas in two consecutive symbol intervals as follows:

- Antenna 1: $\left[a_1, -a_2^*\right]$;
- Antenna 2: $\left[a_2, a_1^*\right]$.

The corresponding received samples are:

$$y_1 = h_1 a_1 + h_2 a_2 + w_1, \tag{15.1}$$

$$y_2 = -h_1 a_2^* + h_2 a_1^* + w_2, \tag{15.2}$$

where w_1 and w_2 are samples from independent identically distributed circular complex white Gaussian noise processes, and h_1 and h_2 are the channel gains from the two transmit antennas to the receiver. The channels are assumed to be flat-fading. Assuming knowledge of the channel gains, the decision variables are obtained by combining the two observations as follows:

$$r_1 = h_1^* y_1 + h_2 y_2^* = \left(|h_1|^2 + |h_2|^2\right) a_1 + h_1^* w_1 + h_2 w_2^*, \tag{15.3}$$

$$r_2 = h_2^* y_1 - h_1 y_2^* = \left(|h_1|^2 + |h_2|^2\right) a_2 + h_2^* w_1 - h_1 w_2^*. \tag{15.4}$$

Then to recover the transmitted symbols, we just have to perform scaling and slicing. The Alamouti decoding was formulated here for the case of flat-fading channels, which is quite a valid model when coding is done within the subcarrier symbol sequences of a Cyclic Prefix Orthogonal Frequency-Division Multiplexing (CP-OFDM) system.

15.3 BLOCKWISE ALAMOUTI SCHEME FOR FBMC/OQAM

Renfors et al. in [5] have proposed a solution to combine the Alamouti scheme with FBMC/OQAM, where the Alamouti coding is performed in a blockwise manner while inserting gaps (zero-symbols and pilots) to isolate the blocks. This solution is feasible when the FBMC/OQAM transmultiplexer response $\boldsymbol{\Gamma}$ (see Section 11.2) is conjugate symmetric along the time axis. Let $\mathbf{A_1}$ and $\mathbf{A_2}$ be two data symbol blocks consisting of N samples in m subcarriers simultaneously transmitted from antenna 1 and antenna 2, respectively. After that, the first antenna transmits $-\overleftarrow{\mathbf{A_2}}^*$, whereas the second one transmits $\overleftarrow{\mathbf{A_1}}^*$. The left arrow on top of a variable denotes the time-reversal version of the corresponding sequence [5]. Assuming that the two channels are constant in time and frequency domains during the transmission of both symbol blocks, the first signal block collected at the receive antenna can be written as

$$\mathbf{Y_1} = h_1\boldsymbol{\Gamma} * \mathbf{A_1} + h_2\boldsymbol{\Gamma} * \mathbf{A_2} + \mathbf{W_1}, \tag{15.5}$$

where $*$ operation stands for the 2D convolution, h_1 and h_2 denote the channel responses from the two transmit antennas to the receive one, and $\mathbf{W_1}$ contains the additive Gaussian noise terms. Likewise, the second received signal block is

$$\mathbf{Y_2} = h_2\boldsymbol{\Gamma} * \overleftarrow{\mathbf{A_1}}^* - h_1\boldsymbol{\Gamma} * \overleftarrow{\mathbf{A_2}}^* + \mathbf{W_2}. \tag{15.6}$$

Naturally, the 2D convolution expands the data blocks, both in time and frequency directions depending on the range of significant Transmultiplexer (TMUX) response elements. We assume that $\mathbf{Y_1}$ and $\mathbf{Y_2}$ are truncated to the size of the transmitted data blocks. We also assume that there is sufficient guard-space in both directions around the transmitted data blocks to prevent leakage from adjacent transmission blocks. The channel is assumed to be constant over the whole transmission block. This is more critical in the time direction because the jointly coded elements appear symmetrically around the center gap. Different subcarriers are treated independently, so the effect of frequency selectivity is assumed to be similar to the case of Single-Input Single-Output (SISO) transmission using single-tap subcarrier equalizers.

Then, we can write

$$\begin{aligned}\overleftarrow{\mathbf{Y_2}}^* &= h_2^*\overleftarrow{\boldsymbol{\Gamma}}^* * \mathbf{A_1} - h_1^*\overleftarrow{\boldsymbol{\Gamma}}^* * \mathbf{A_2} + \overleftarrow{\mathbf{W_2}}^* \\ &= h_2^*\boldsymbol{\Gamma} * \mathbf{A_1} - h_1^*\boldsymbol{\Gamma} * \mathbf{A_2} + \overleftarrow{\mathbf{W_2}}^*. \end{aligned}\tag{15.7}$$

The last equality stands thanks to the fact that $\boldsymbol{\Gamma}$ is conjugate symmetric along the time axis ($\overleftarrow{\boldsymbol{\Gamma}}^* = \boldsymbol{\Gamma}$). Therefore, applying the Alamouti decoding [4], we have

$$\mathbf{R_1} = \frac{h_1^*\mathbf{Y_1} + h_2\overleftarrow{\mathbf{Y_2}}^*}{|h_1|^2 + |h_2|^2} = \boldsymbol{\Gamma} * \mathbf{A_1} + \frac{h_1^*\mathbf{W_1} + h_2\overleftarrow{\mathbf{W_2}}^*}{|h_1|^2 + |h_2|^2} \tag{15.8}$$

and

$$\mathbf{R_2} = \frac{h_2^*\mathbf{Y_1} - h_1\overleftarrow{\mathbf{Y_2}}^*}{|h_1|^2 + |h_2|^2} = \boldsymbol{\Gamma} * \mathbf{A_2} + \frac{h_2^*\mathbf{W_1} - h_1\overleftarrow{\mathbf{W_2}}^*}{|h_1|^2 + |h_2|^2}. \tag{15.9}$$

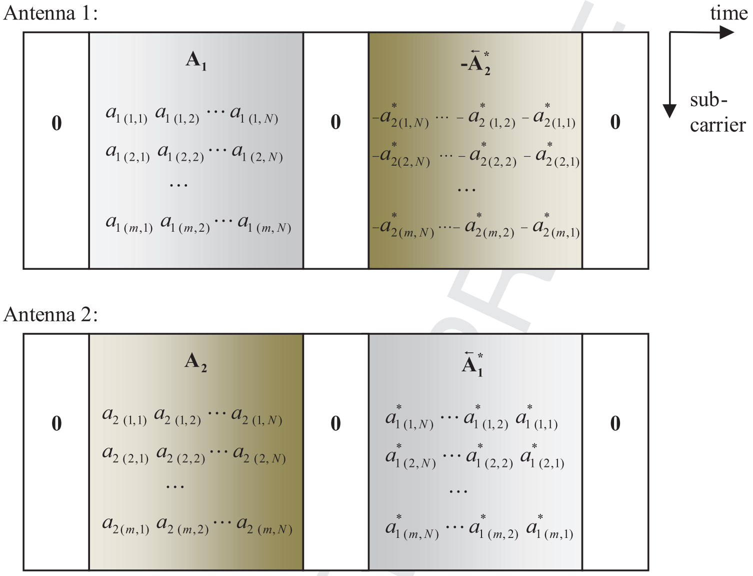

FIGURE 15.1

Alamouti-coded frame at SFB input.

The term $\mathbf{\Gamma} * \mathbf{A_i}$ contains the transmitted data symbols and also the intrinsic interference. We can write it as in [5]:

$$\mathbf{\Gamma} * \mathbf{A_i} = \mathbf{D_i} + \mathbf{U_i}, \tag{15.10}$$

where $\mathbf{U_i}$ is the block of the interference terms. When a data symbol in $\mathbf{A_i}$ is purely real, its corresponding interference term in $\mathbf{U_i}$ is purely imaginary. Then, the transmitted data symbols are easily estimated by a simple real part retrieval.

15.3.1 FRAME STRUCTURE

The frame structure for blockwise Alamouti transmission is illustrated in Fig. 15.1. The frame consists of a number of adjacent subcarriers and $2N$ Offset Quadrature Amplitude Modulation (OQAM) subsymbols of data in each subcarrier within each frame.

We consider FBMC/OQAM systems that are well localized in frequency. Typically, the transition bands of a subchannel are overlapping only with the immediately adjacent subchannels. Assuming relatively mild-frequency selectivity in the subcarrier bandwidth, the near-orthogonality of subcarriers is maintained by the Alamouti detection scheme, which basically implements one-tap subcarrier equalization through the maximum ratio combining process. In synchronized transmission, different users' code blocks can be placed right next to each other in the frequency direction. In asynchronous transmission, like multiuser uplink, the transmission blocks can be well isolated from each other in the frequency direction by leaving an empty subcarrier as a guardband between blocks.

In the basic scheme, zero-samples are inserted in all subcarriers between the Alamouti-coded frames and also between the two parts of each Alamouti coded frame (these are referred to as the edge gaps and center gap, respectively). Assuming that the filter bank overlapping factor is $K = 4$, a gap of four subcarrier samples (two OQAM symbols) is needed to isolate the blocks completely. With three zero samples, the crosstalk between the blocks is still at a very low level. Also shorter distances may be considered, depending on the targeted Signal-to-Noise Ratio (SNR) operation range. Since the intrinsic interference within each part of the coded frame is canceled by the block Alamouti scheme, it is not able to cope with the intrinsic interference across the two parts. Therefore, a sufficient guard space is needed between them. There is no such hard restriction for the edge gap length. Actually, nonzero repetitive sample sequences can be inserted in the edge gaps without distorting the symmetry required by the Alamouti-coded block pairs. A natural way to make use of this opportunity is to embed pilots (training sequences) in the edge blocks. Feasible block sequences for the two transmit antennas can be represented as follows:

$$\begin{cases} \mathbf{T_1} &= \left[\mathbf{P_1}, \mathbf{A_1}, \mathbf{0}, -\overleftarrow{\mathbf{A_2}}^*, -\overleftarrow{\mathbf{P_2}}^*, \mathbf{A_3}, \mathbf{0}, -\overleftarrow{\mathbf{A_4}}^*, -\mathbf{P_1}, \cdots\right], \\ \mathbf{T_2} &= \left[\mathbf{P_2}, \mathbf{A_2}, \mathbf{0}, \overleftarrow{\mathbf{A_1}}^*, \overleftarrow{\mathbf{P_1}}^*, \mathbf{A_4}, \mathbf{0}, \overleftarrow{\mathbf{A_3}}^*, -\mathbf{P_2}, \cdots\right]. \end{cases} \tag{15.11}$$

Here $\mathbf{P_1}$ and $\mathbf{P_2}$ are arbitrarily chosen pilot symbol blocks.

Pilot blocks following this structure introduce no more interference to the data symbols than zero samples in these places, assuming stationary nonfrequency-selective subchannels. Naturally, there is some interference between different Alamouti code frames if the length of the pilot block is lower than K samples. The received secondary parts of the pilot symbols are not under control in this scheme, but this is not critical for the channel estimation scheme introduced in [5].

15.3.2 PERFORMANCE EVALUATION

The blockwise Alamouti scheme was tested using the International Telecommunication Union Radiocommunication (ITU-R) Vehicular-A (Veh-A) channel model and Worldwide Interoperability for Microwave Access (WiMAX)-like system parameters with $M = 1024$ subcarriers and subcarrier spacing of $\Delta f = 10.94$ kHz. The PHYDYAS filterbank with overlapping factor $K = 4$ is applied in this study. Block-fading channel model is assumed, i.e., the channel remains constant over each Alamouti code frame, and the results show average performance over 1000 independent channel instances. With these parameters, the subchannels are essentially flat-fading, and single-tap subchannel equalizers provide sufficient performance. Quadrature Phase-Shift Keying (QPSK) subcarrier modulation is applied for data, and random QPSK sequences are used as pilots. We apply a specific channel estimation approach proposed in [5], which utilizes the pilot structure of Eqs. (15.11).

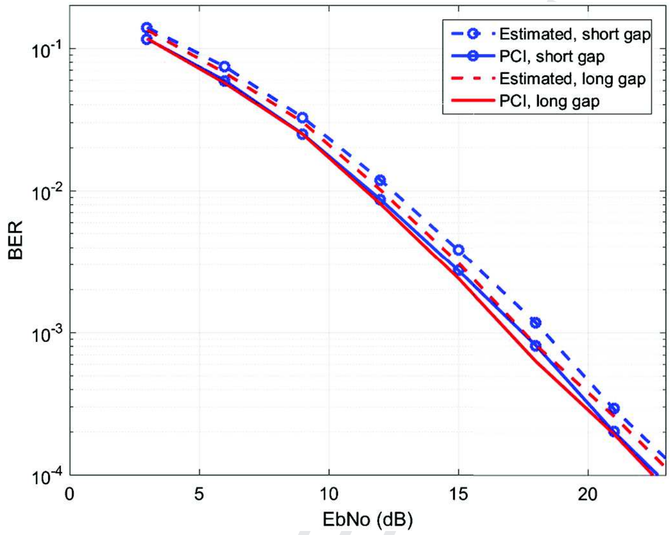

FIGURE 15.2

BER performance of blockwise Alamouti scheme with FBMC/OQAM, QPSK modulation, and Veh-A channel.

It was found that three subcarrier samples is the best choice for the pilot sequence length. We use the two pilot blocks that are closest to each Alamouti code frame for estimating the channel for that frame. We consider using pilots also from the immediately adjacent subchannels. More specifically, for an Alamouti code frame on subcarrier m starting at time index n and ending at $n + n_0$, we use twelve pilots samples with sample indices $n - 2$, $n - 1$, $n + n_0 + 1$, and $n + n_0 + 2$ at subcarriers $m - 1$, m, and $m + 1$ for estimating the channel gain. Regarding the center gap length, both 1 and 3 samples are considered, and as mentioned, the samples in the center gap are all zero. Aiming at pilot overhead of one pilot symbol per six data symbols, we choose Alamouti code block length as 9 OQAM symbols (18 subcarrier samples) or 6 OQAM symbols (12 samples) for the long gap and short gap, respectively. The distance between consecutive pilot blocks is about 20 or 13 OQAM symbols, respectively. The average pilot symbol energy is boosted by 2.5 dB above average data symbol energy.

Fig. 15.2 shows the average Bit Error Rate (BER) performance as a function of E_b/N_0 for both pilot schemes and QPSK data modulation. We can see that the performance is quite acceptable also with the shorter center gap. Fig. 15.3 shows the average BER performance as a function of mobile velocity, with 2.5 GHz carrier frequency for both pilots schemes. We can see that the shorter frame length, enabled by shorter gap, is clearly more robust with significant mobility.

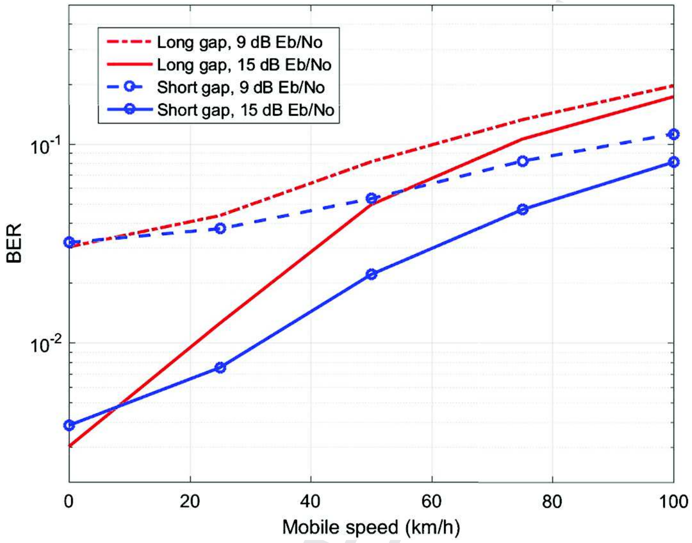

FIGURE 15.3

BER performance for blockwise Alamouti scheme with FBMC/OQAM as a function of mobility. QPSK modulation, E_b/N_0 of 9 or 15 dB, Veh-A channel, pilot block length of 3 samples, 0-block length of 1 or 3 samples.

15.4 INTERFERENCE CANCELLATION IN ALAMOUTI CODING SCHEME FOR FBMC/OQAM

To remove the interference term, some works based on iterative interference estimation and cancellation have also been carried out. Unfortunately, detection schemes with interference estimation and cancellation are subject to error propagation and are not always effective [6]. Therefore, the challenge in this kind of schemes is to mitigate the error propagation through iterations [7]. To counteract the error propagation and make the cancellation scheme effective, the authors in [7] have shown that a necessary condition to avoid the error propagation is to hold the interference power under a certain threshold, i.e., the interference cancellation technique can only be effective when the Inter-Symbol Interference (ISI) is small enough compared to the minimal distance between two different symbols.

To reduce the power of the intrinsic interference, it was proposed in [8] to modify the conventional FBMC/OQAM system by using Quadrature Amplitude Modulation (QAM) symbols instead of OQAM ones and transmitting the data symbols on each period T instead of transmitting them on each half period $T/2$. That is, the authors utilize the conventional lattice structure of OFDM with complex-valued symbols and localized filters. Thus, the interference coefficients corresponding to the odd multiples of $T/2$ are avoided, and the overall interference power is reduced. However, as a consequence of this modification, the real orthogonality condition of

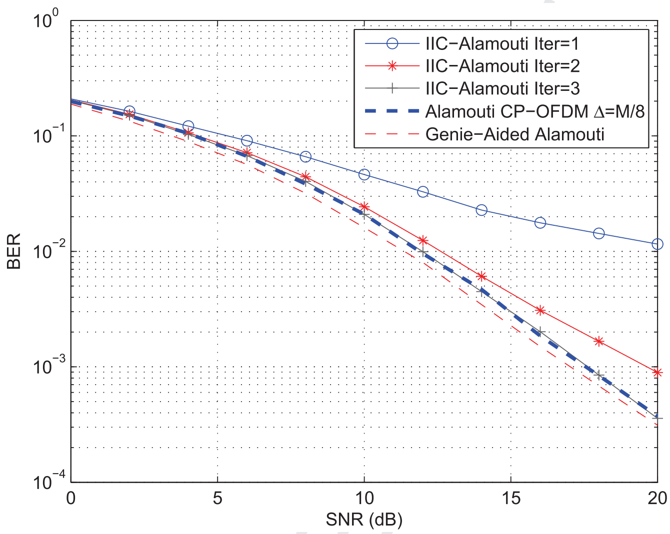

FIGURE 15.4

Performance of IIC-Alamouti receiver with FBMC-QAM using PHYDYAS filter and 4-QAM constellation.

FBMC/OQAM is no longer satisfied. Therefore, even in SISO system, interference cancellation methods must be applied at the receiver. As for the STBC decoding, a first Alamouti decoder is used as tentative detector providing tentative estimations of the data symbols. Based on these tentative estimates, the interference canceler calculates an estimation of the interference, and then its contribution is removed from the received vector. After that, the Alamouti decoding is again applied, and the operation is repeated several times. The authors in [8] show by simulations that Alamouti coding scheme with Iterative Interference Cancellation (IIC) applied in FBMC-QAM provides satisfactory performance. Fig. 15.4 depicts the BER performance obtained of the IIC-Alamouti in FBMC-QAM with three iterations and compare them to the OFDM and genie-aided Alamouti performance. This latter is obtained by assuming perfect intrinsic interference cancellation. We observe an SNR loss of only 0.5 dB compared to the genie-aided performance. Nevertheless, the IIC-Alamouti in the FBMC-QAM system exhibits almost the same performance as that obtained with OFDM; this is due to the E_b/N_0 loss caused by the Cyclic Prefix (CP) in OFDM.

Another technique aiming to reduce the intrinsic interference power is introduced in [9]. The authors propose some arrangements in the STBC and Space Frequency Block Code (SFBC) schemes to reduce the FBMC/OQAM intrinsic interference and improve the Signal-to-Interference Ratio (SIR). The idea behind these arrangements is to automatically remove an important part of the interference only by performing the adequate Alamouti decoding. Then, the remaining interference is canceled iteratively by interference estimation and cancellation procedure. The selected ar-

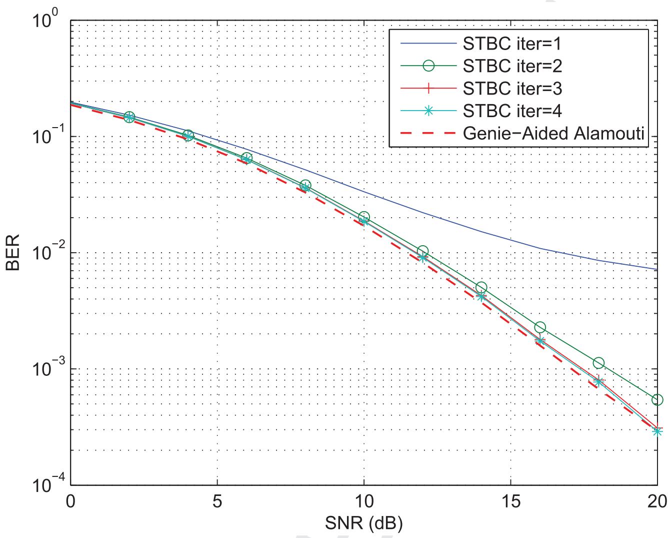

FIGURE 15.5

Performance of the proposed STBC scheme in FBMC/OQAM using OQPSK modulation.

rangement that minimizes the remaining interference operates on two interleaved Alamouti blocks (in time or frequency domain). Furthermore, there is an alternating rule in position of the minus sign between both blocks. The proposed Alamouti schemes applied in FBMC/OQAM were tested in [9], and it was shown that the BER performance curves converge to the interference-free performance. More specifically, the BER performance with Offset Quadrature Phase-Shift Keying (OQPSK) mapping is shown in Fig. 15.5. The BER performance of the first iteration corresponds to the tentative Alamouti decoding, and the BER floor at 7×10^{-3} is due to the remaining interference. However, we can observe that the performance curves reach the genie-aided performance after three iterations.

It is worth noticing that the weakness of these IIC receivers is the fact that the performance is promptly decayed when higher mapping orders are considered [8,9].

15.5 OTHER SOLUTIONS

In the previous sections, two proposed solutions for FBMC/OQAM-Alamouti were presented. Both solutions deal with the intrinsic interference of FBMC/OQAM without any change in the modulator structure. On the other hand, some other solutions have been also proposed by slightly changing the FBMC/OQAM modulator/demodulator architecture. These proposals will be more specifically reviewed in this section.

15.5.1 PSEUDO-ALAMOUTI SCHEME FOR CP-FBMC

An OQAM modulation with CP, called CP-OQAM, was proposed in SISO case to perfectly cancel the interference [10]. The main idea is that the symbols first go through an OQAM modulator. Then the modulated signal is grouped into successive blocks of size M (subcarrier number). Then a CP is appended to each block before transmitting. At the receiver side, the signal is first converted to parallel blocks, and then CP is removed from each block. Thus, the channel matrix is transformed into a circulant channel matrix, which can be diagonalized by Discrete Fourier Transform (DFT). A Zero Forcing (ZF) equalization is carried out after applying the Fast Fourier Transform (FFT). Then, the signals are transformed back to time domain by IFFT, and, finally, the ZF equalized signal is fed to the OQAM demodulator. The pseudo-Alamouti coding scheme in [11] is an extension of the CP-FBMC SISO transceiver to 2×1 Multiple-Input Single-Output (MISO) system with an adaptation of the Alamouti coding/decoding. Indeed, the Alamouti encoder is performed after the OQAM modulator in a blockwise manner with the block size of M symbols. To keep the Alamouti orthogonality, both symbol blocks transmitted simultaneously at the second period are reversed. The Alamouti decoding is performed instead of the ZF equalization after the first FFT. The authors in [11] show by simulations that due to a specific and efficient channel estimation method [12], the proposed pseudo-Alamouti transceiver can outperform the Alamouti OFDM scheme. Nevertheless, it is worth noting that the simulation results in [11] are obtained by considering a prototype filter with an overlapping factor of $K = 1$. This avoids any interference between useful data in the time domain.

15.5.2 ALAMOUTI CODING SCHEME FOR CDMA-FBMC

It was shown in [3] that Alamouti coding can be employed in combination with Code-Division Multiple Access (CDMA). Indeed, it is shown in [13] that it is possible to have a complex orthogonality with FBMC thanks to Walsh–Hadamard CDMA codes. This is because the CDMA despreading operation allows us to recover a complex orthogonality property in FBMC/OQAM. Therefore, the principle in this proposal is to take advantage of the orthogonality property resulting from the CDMA-OFDM/OQAM combination to get a new Multiple-Input Multiple-Output (MIMO) Alamouti scheme with FBMC.

Two different approaches with Alamouti coding are proposed by considering a CDMA spreading either in the frequency or in the time domain. If the CDMA spreading is carried out in the frequency domain, the Alamouti decoding scheme can only be applied if the channel is assumed to be spectrally flat. For the Alamouti scheme with time spreading CDMA-OFDM/OQAM, two strategies are elaborated for implementing the MIMO space-time coding scheme. Strategy 1 implements the Alamouti over pairs of adjacent frequency domain samples, whereas Strategy 2 processes the Alamouti coding scheme over pairs of spreading codes from two successive time instants. The authors show that Strategy 2 appears to be more appropriate since it requires less restrictive assumptions on the channel variations across the frequencies. Therefore, under some channel hypotheses, the combination of Alamouti with complex CDMA-OFDM/OQAM is possible without increasing the complexity of the Alamouti decoding process. Furthermore, in the case of a frequency selective channel, FBMC/OQAM keeps its intrinsic advantage with an SNR gain in direct relation with the CP length.

15.5.3 ALAMOUTI SPACE-TIME CODE IN FFT-FBMC

To mitigate the problem of inherent interference in FBMC, a modified version of the system was developed in [14,15]. The basic idea was to view the interference term as the result of three linear Finite Impulse Response (FIR) filters, one for each subcarrier (the subcarrier under question plus the preceding and following ones). Then, OFDM is mimicked for each of the three terms to come up with a system that is formulated as OFDM and hence facilitates detection at the receiver. Hence, the authors introduce, before the (usual) IFFT block of size M in the FBMC scheme, another IFFT precoding block of size N for each subcarrier, optionally followed by a CP insertion. The CP prevents ISI in time domain, whereas it is shown that a specific arrangement of the block data symbols setting half of them to zero and the other ones to complex-values (instead of real-valued for the conventional FBMC/OQAM system) can prevent from Inter-Carrier Interference (ICI). Moreover, this specific arrangement makes the FFT-FBMC spectrum more confined than the one of FBMC [16]. The authors show that the equivalent system can be formulated as OFDM, and any MIMO technique can be applied in a straightforward manner. Indeed, it is shown that the equivalent system model can be given by [15]

$$y_q[n] \cong H_q F_{0,n}^{(q)} d_q[n] + w_q[n], \qquad (15.12)$$

where $w_q[n]$ is the noise term at the output of the demodulator, H_q is the channel coefficient, and $F_{0,n}^{(q)}$ is a real coefficient greater than 1, which depends on the prototype filter. Hence, according to the above expression of the system model, Alamouti coding could be performed straightforwardly. Indeed, the performance of the Alamouti coding with FFT-FBMC scheme is evaluated in [15]. Since the proposed FFT-FBMC includes CP at each subcarrier, an effort is also devoted to assess the performance loss when reducing the CP length. Simulation results showed that we can almost obtain the same performance as OFDM in some configurations. Fig. 15.6 depicts the BER performance of the Alamouti coding with FFT-FBMC using the PHYDYAS filter for different configurations according to extra FFT block length N and the CP length L. The performance curves are also compared to the curve of OFDM-Alamouti performance.

We can observe that the FFT-FBMC obtains almost no degradation compared to OFDM, except for the case where $N = 16$ and $L = 0$, where we have about a 2.75 dB SNR loss with respect to OFDM at $BER = 10^{-4}$ and less than 1 dB at $BER = 10^{-2}$. Furthermore, the avoidance of the CP does not result in considerable degradations. We can notice, at worst, about 1 dB of SNR loss at $BER = 10^{-4}$ (except for $N = 16$).

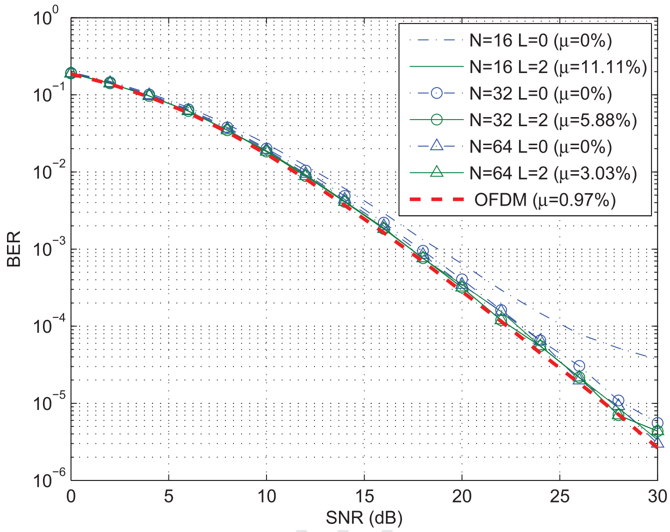

FIGURE 15.6

Performance of FFT-FBMC using PHYDYAS prototype filter with (2×1) Alamouti coding scheme and QPSK modulation in Ped-A channel.

15.6 CONCLUDING REMARKS

Because of its intrinsic interference, the full potential performance of FBMC/OQAM cannot be straightforwardly reached when combined with the Alamouti coding. Therefore, specific signal processing techniques had to be developed and used. In this chapter, an overview of known solutions for FBMC/OQAM with Alamouti coding was presented. We have mainly detailed two schemes dealing with the intrinsic interference without changing the structure of the FBMC/OQAM modulator/demodulator. Other solutions have been also presented, which require some modifications in the original FBMC/OQAM structure such as appending a CP. All the different overviewed solutions for FBMC/OQAM-Alamouti offer good performance at the expense of either complexity increase or spectral efficiency reduction.

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NON-PRINT ITEMS

ABSTRACT

The introduction of multiple antennas at the transmitter and/or at the receiver provides spatial diversity in the system. This spatial diversity can be exploited using Space Time Block Code (STBC) or Space-Time Trellis Coding (STTC). However, these spatial diversity schemes cannot be straightforwardly applied with FBMC/OQAM due to the intrinsic interference. Many research works have been carried out to deal with this issue. This chapter gives an overview of the most significant contributions, with focus on blockwise and interference cancellation based Alamouti schemes.

KEYWORDS

Viterbi algorithm, Alamouti code, White Gaussian noise process, Cyclic prefix orthogonal frequency-division multiplexing system, Offset quadrature amplitude modulation, Mild-frequency selectivity, Filter-bank multicarrier, Space-time block coding, Space-time trellis coding