B978-0-12-810384-5.00015-3, 00015

CHAPTER

15 Space-Time Coding for FBMC/OQAM

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

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

Tampere University of Technology, Tampere, Finland†

CONTENTS

15.1 Introduction 407
15.2 Basic Alamouti Coding Principle 408
15.3 Blockwise Alamouti Scheme for FBMC/OQAM 408
15.3.1 Frame Structure 410
15.3.2 Performance Evaluation 411
15.4 Interference Cancellation in Alamouti Coding Scheme for FBMC/OQAM 413
15.5 Other Solutions 415
15.5.1 Pseudo-Alamouti Scheme for CP-FBMC 416
15.5.2 Alamouti Coding Scheme for CDMA-FBMC 416
15.5.3 Alamouti Space-Time Code in FFT-FBMC 417
15.6 Concluding Remarks 418
References 418

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

RENFORS, 978-0-12-810384-5

LaTeX class: renfors, v. 2017/03/24, v1.00 class driver for RENFORS project (P04-1C)
RENFORS model: p04 ref-style: undef file: renfors15.tex (EA) Prn:2017/05/15; 16:44 p. 1

B978-0-12-810384-5.00015-3, 00015

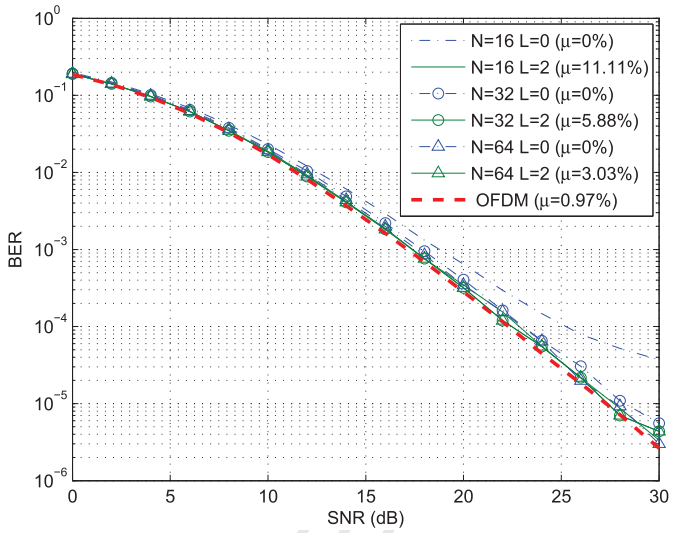

FIGURE 15.6

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.

REFERENCES

[1] M. Bellanger, "Transmit diversity in multicarrier transmission using OQAM modulation," in *3rd International Symposium on Wireless Pervasive Computing, ISWPC 2008*, May 2008, pp. 727–730.

[2] C. Lele, D. L. Ruyet, and R. Zakaria, "On the decoding of single delay STTC using filter bank based multicarrier modulation," in *2009 6th International Symposium on Wireless Communication Systems*, Sep. 2009, pp. 86–90.

LaTeX class: renfors, v. 2017/03/24, v1.00 class driver for RENFORS project (P04-1C)
RENFORS model: p04 ref-style: undef file: renfors15.tex (EA) Prn:2017/05/15; 16:44 p. 12

B978-0-12-810384-5.00015-3, 00015

[3] C. Lélé, P. Siohan, and R. Legouable, "The Alamouti scheme with CDMA-OFDM/OQAM," *EURASIP Journal on Advances in Signal Processing*, vol. 2010, 2010. [Online]. Available: http://dblp.uni-trier.de/db/journals/ejasp/ejasp2010.html#LeleSL10.

[4] S. Alamouti, "A simple transmit diversity technique for wireless communications," *IEEE Journal on Selected Areas in Communications*, vol. 16, no. 8, pp. 1451–1458, Oct. 1998.

[5] M. Renfors, T. Ihalainen, and T. Stitz, "A block-Alamouti scheme for filter bank based multicarrier transmission," in *Wireless Conference (EW), 2010 European*, Apr. 2010, pp. 1031–1037.

[6] R. Zakaria and D. Le Ruyet, "Partial ISI cancellation with Viterbi detection in MIMO filter-bank multicarrier modulation," in *8th International Symposium on Wireless Communication Systems (ISWCS)*, Nov. 2011, pp. 322–326.

[7] O. Agazzi and N. Seshadri, "On the use of tentative decisions to cancel intersymbol interference and nonlinear distortion (with application to magnetic recording channels)," *IEEE Transactions on Information Theory*, vol. 43, pp. 394–408, Mar. 1997.

[8] R. Zakaria and D. L. Ruyet, "Intrinsic interference reduction in a filter bank-based multicarrier using QAM modulation," *Physical Communication*, vol. 11, pp. 15–24, 2014.

[9] R. Zakaria and D. Ruyet, "On interference cancellation in Alamouti coding scheme for filter bank based multicarrier systems," in *Proceedings of the Tenth International Symposium on Wireless Communication Systems (ISWCS 2013)*, Aug. 2013, pp. 1–5.

[10] H. Lin and P. Siohan, "A new transceiver system for the OFDM/OQAM modulation with Cyclic Prefix," in *IEEE 19th International Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC 2008*, Sep. 2008, pp. 1–5.

[11] H. Lin, C. Lélé, and P. Siohan, "A pseudo Alamouti transceiver design for OFDM/OQAM modulation with cyclic prefix," in *IEEE 10th Workshop on Signal Processing Advances in Wireless Communications, SPAWC '09*, Jun. 2009, pp. 300–304.

[12] C. Lélé, J.-P. Javaudin, R. Legouable, A. Skrzypczak, and P. Siohan, "Channel estimation methods for preamble-based OFDM/OQAM modulations," in *European Wireless*, Paris, France, Apr. 2007.

[13] C. Lélé, P. Siohan, R. Legouable, and M. Bellanger, "CDMA transmission with complex OFDM/OQAM," *EURASIP Journal on Wireless Communications and Networking*, vol. 2008, 2008.

[14] R. Zakaria and D. Le Ruyet, "A novel FBMC scheme for spatial multiplexing with maximum likelihood detection," in *7th International Symposium on Wireless Communication Systems (ISWCS)*, Sep. 2010, pp. 461–465.

[15] R. Zakaria and D. Le Ruyet, "A novel filter-bank multicarrier scheme to mitigate the intrinsic interference: Application to MIMO systems," *IEEE Transactions on Wireless Communications*, vol. 11, pp. 1112–1123, Mar. 2012.

[16] R. Zakaria and D. Le Ruyet, "Theoretical analysis of the power spectral density for FFT-FBMC signals," *IEEE Communications Letters*, vol. 20, pp. 1748–1751, Sep. 2016.

LaTeX class: renfors, v. 2017/03/24, v1.00 class driver for RENFORS project (P04-1C)
RENFORS model: p04 ref-style: undef file: renfors15.tex (EA) Prn:2017/05/15; 16:44 p. 13

B978-0-12-810384-5.00015-3, 00015

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