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Development of OFDM Space Coded Outdoor Wireless Link

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ABSTRACT: *This paper represents an end-to-end baseband model of the physical layer of outdoor wireless link.Specifically it models the OFDM-based physical layer called Wireless OFDM, supporting all of the mandatory coding and modulation options. It also illustrates Space-Time Block Coding (STBC), an optional transmit diversity scheme specified for use on the downlink.*
Keywords - *MIMO OFDM, STBC,REED SOLOMAN,SNR,FFT.*

I. INTRODUCTION

Orthogonal frequency-division multiplexing, or OFDM, is a process of digital modulation that is used in computer technology today. Essentially, OFDM is configured to split a communication signal in several different channels. Each of these channels is formatted into a narrow bandwidth modulation, with each channel operating at a different frequency. The process of OFDM makes it possible for multiple channels to operate within close frequency levels without impacting the integrity of any of the data transmitted in any one channel One major advantage of OFDM is that it is bandwidth efficient. What that really means is that you can transmit more data faster in a given bandwidth in the presence of noise. The measure of spectral efficiency is bits per second per Hertz, or bps/Hz. For a given chunk of spectrum space, different modulation methods will give widely varying maximum data rates for a given bit error rate (BER) and noise level.

II. SPACE TIME BLOCK CODED OFDM

Performance of OFDM system is improved by increasing the diversity gain. By using Space Time Block Code the antenna diversity gain can be increased. Severe attenuation in a multipath wireless environment makes it extremely difficult for the receiver to determine the transmitted signal unless the receiver is provided with some form of diversity i.e. some less-attenuated replica of the transmitted signal is provided to the receiver. In some applications, the only practical means of achieving diversity is deployment of antenna array at the transmitter and/or receiver end. As the current trend of communication systems demands highly power-efficient and bandwidth-efficient schemes, techniques that provide such desirable properties are considered very valuable in next generation wireless systems. Making use of multiple antennas increases the capacity of the system with the associated higher data rates than single antenna systems. Space-Time coding is a power-efficient and bandwidth-efficient method of communication over fading channels by using multiple transmits antennas systems. In this paper Orthogonal Frequency Division Multiplexed (OFDM) system using 192 sub-carriers, 8 pilots, 256-point FFTs, and a variable cyclic prefix length is simulated. For Space-Time Block Coding using Alamouti's [3] scheme used.

III. DEVELOPMENT OF OFDM SIMULATION MODEL

By using simulink test bench in matlab a simulation model is developed. The main features and assumptions are given below. This paper showcases the main components of the outdoor wireless OFDM physical layer using STBC which has all the mandatory coding and modulation options as described below.

- Generation of random bit data that models a downlink burst consisting of an integer number of OFDM symbols.
- Forward Error Correction (FEC), consisting of a Reed-Solomon (RS) outer code concatenated with a rate-compatible inner convolution code (CC).
- Data interleaving.
- Modulation, using one of the BPSK, QPSK, 16-QAM or 64-QAM constellations specified.
- Orthogonal Frequency Division Multiplexed (OFDM) transmission using 192 sub-carriers, 8 pilots, 256-point FFTs, and a variable cyclic prefix length.
- Space-Time Block Coding using Alamouti's [3] scheme. This is implemented using the OSTBC Encoder and Combiner blocks in Communications Blockset.
- A single OFDM symbol length preamble that is used as the burst preamble. For the optional STBC model, the single symbol preamble is transmitted from both antennas.
- A Multiple-Input-Single-Output (MISO) fading channel with AWGN for the STBC model. A choice of non-fading, flat-fading or dispersive multipath fading channel for the non-STBC model.

- OFDM receiver that includes channel estimation using the inserted preambles. For the STBC model, this implies diversity combining as per [3].
- Hard-decision demodulation followed by deinterleaving, Viterbi decoding, and Reed-Solomon decoding. Model has an adaptive-rate control scheme based on SNR estimates at the receiver to vary the data rate dynamically based on the channel conditions. The models use following seven rates for OFDM-PHY, each corresponding to a specific modulation and RS-CC code rate as denoted by rate_ID (see Table1 below as per [1]).

Table 1: Modulation Techniques rate ID's

Rate_ID	Modulation RS-CC rate
0	BPSK 1/2
1	QPSK 1/2
2	QPSK 3/4
3	16-QAM 1/2
4	16-QAM 3/4
5	64-QAM 2/3
6	64-QAM 3/4

- The STBC link model uses a MISO fading channel to model a two transmitter, one receiver (2x1) system. The fading parameters specified are assumed to be identical for the two links. The Space-Time Diversity Combiner block uses the channel estimates for each link and combines the received signals as per [3]. The combining involves simple linear processing using the orthogonal signaling employed by the encoder.
- Furthermore, the models include blocks for measuring and displaying the bit error rate after FEC, the channel SNR and the rate_ID. A scatter plot scope is used to display the received signal, which helps users visualize channel impairments and modulation adaptation as the simulation runs.

IV. ASSUMPTIONS

- It is assumed that the number of OFDM symbols to be constant for all data bursts generated. As a result, for any given profile, the frame duration in Simulink remains the same. Note that within the downlink frame only the downlink bursts are modelled, i.e. the long preamble and the FCH burst are not modelled.
- Do not model the Randomization specified as a part of the channel coding as the data is randomly generated.
- It is assumed that there is perfect synchronization between the transmitter and receiver. As a consequence, they only use a short preamble for every downlink burst.
- At the receiver, estimate the channel using only the inserted preambles and not the pilot subcarriers. This assumes that the channel is not changing very rapidly (or is constant for the number of OFDM symbols in a burst).
- A six-element vector is specified for SNR ranges. System will choose specific bit rate on the basis of SNR values. Ideally, the simulation should use the highest throughput mode that achieves the desired bit error rate.

V. FIGURES AND DISPLAYS

When model is simulated, for specific simulation time we get the spectrum plots of the transmitted signal per antenna and a scatter plot of the received signal prior to demodulation

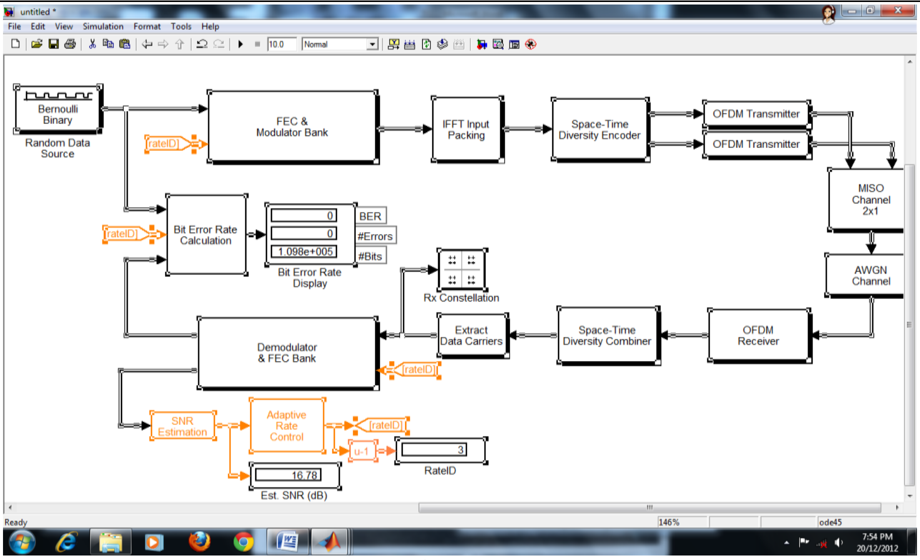

Fig.1- Simulink model for OFDM-MISO outdoor link.

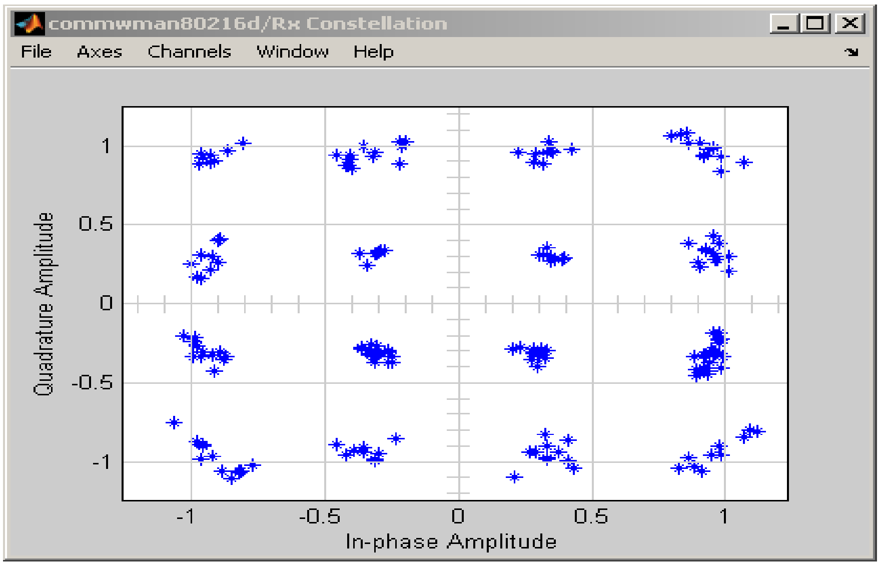

Fig.2- Scatter plot before demodulation

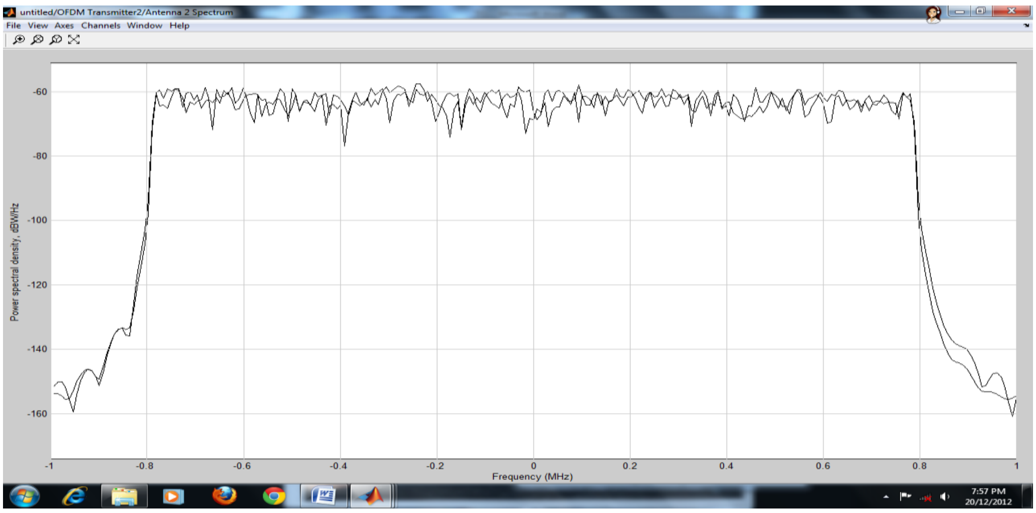

Fig.3- Spectrum plot for antenna 1

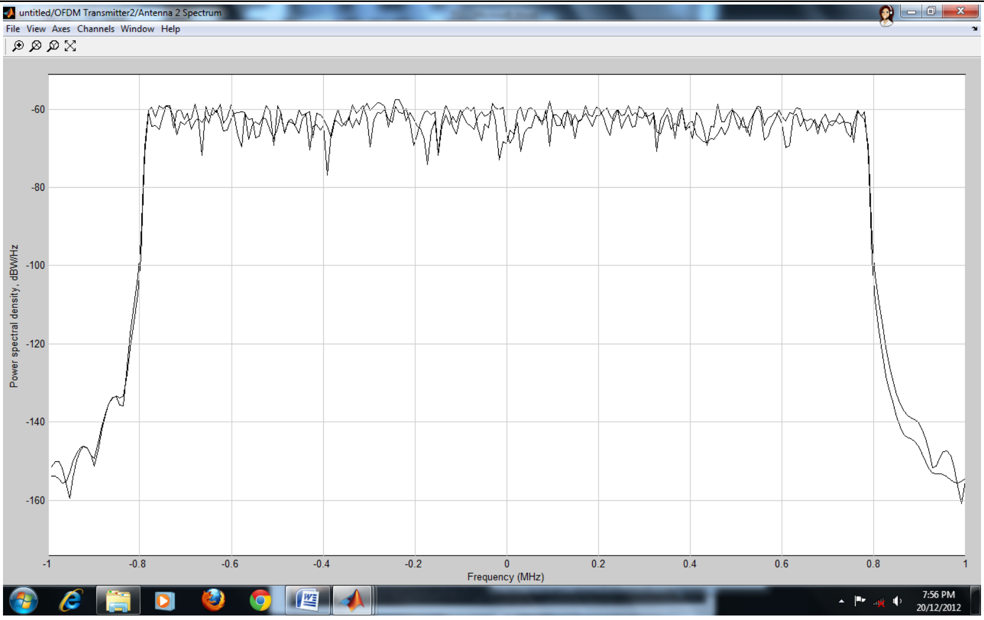

Fig.4- Spectrum plot for antenna 2

VI. CONCLUSION

This paper simulates STBC OFDM 2x1 system for specified modulation and coding schemes. The decision is taken on the basis of channel conditions. The performance is still improved by increasing antenna diversity (More no. antenna) and different rate adaptive schemes.

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