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# Multisymbol Techniques for Efficient OFCDM System

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***Abstract*— Future 4G system required transmission of richer multimedia services it essential to increase the downlink capacity.. This paper deals with our proposed technique 4D (four-dimensional) orthogonal variable spreading factor (OVSF) code for efficient multiple input multiple output orthogonal frequency code division multiplexing (MIMO OFCDM) system which shows better performance as compare to MIMO OFCDM system with 1D and 2D OVSF codes in 4 generation (4G). .So in this paper we study the detail of variable spreading factor orthogonal frequency and code division multiplexing (VSF-OFCDM) systems. Comparison and evaluation of 2D OFCDM system with 1D OVSF code and 2D OVSF code and 4D OVSF code. 2D VSF-OFCDM systems with various 2D spreading factors (SF) are done in time and in frequency domain. The simple bit error rate reduction approach based on multi symbol techniques for efficient OFCDM system in 4G and is also evaluated.***

***Keywords*— OVSF-OFCDM with 1D OVSF code, 2D OVSF code, 4D OVSF code**

## I. INTRODUCTION

In wireless communication systems, electromagnetic energy that is carrying data propagates from transmit antennas to receive antennas. Major problems raised in electromagnetic wave propagation are the multipath fading and multiple access interference (MAI). When the transmitted signal arrives at the receiver through different propagation paths with different delays, intersymbol interference may occur. Moreover, signals via different paths may be destructive due to phase difference, and this phenomenon is called signal fading. Reflection, diffraction, and scattering are three major mechanisms that cause multipath propagation. A MIMO system can support high-data-rate applications and improve received signal quality in a transmission system where the transmitted signal experiences multipath fading and noise degradation, a combining technique is needed to identify and combine the components from the same transmitted signal. These combining techniques can generally be grouped into selection combining (SC), gain combining, and hybrid selection/gain combining. In selection combining, the received signal from the transmission path with the highest signal-to-noise ratio (SNR) is selected for detection. However in gain combining, signals from all transmission paths are combined to detect the transmitted data. Some typical gain combining techniques are maximal ratio combining (MRC), equal gain combining (EGC), and minimum mean-square error (MMSE) combining. System bandwidth, transmission rate, and error probability are three main characteristics in evaluating wireless communication systems. To optimize the use of available bandwidth is one of the major topics in the study of wireless communication systems. Multiple-access systems provide a solution for optimizing frequency use and maximizing flexibility. For instance, frequency-division multiple access (FDMA), time-division multiple access (TDMA), spread spectrum multiple access (SSMA), and space-division multiple access (SDMA) are well investigated and implemented in different communication systems. Also, orthogonal frequency-division multiplexing (OFDM) is one useful multiplexing scheme that has attracted many researchers .It divides data into a set of parallel streams to be transmitted using mutually orthogonal frequency bands. Because of this orthogonality, the data streams transmitted at the same time to increase the system transmission rate. On the other hand, CDMA is one form of "spread-spectrum" signaling that is broadly used in telecommunication systems. In a CDMA system, users are assigned orthogonal codes so that different users can share the same frequency band at the same time with little or no interference. One integration of OFDM and CDMA techniques, called OFCDM, takes advantage of both OFDM and CDMA systems to gain frequency diversity and achieve high but flexible transmission rates can be with two-dimensional spreading. OFCDM is an attractive transmission technique for high-data-rate applications. In OFCDM, spreading in frequency domain provides frequency diversity gain. On the other hand, a large time domain spreading factor allows more users to access the system at the same time, whereas a small time domain spreading factor is more suitable for high-data-rate applications. Combined with MIMO technology, a MIMO-OFCDM system can provide high reliability with flexible transmission rates. We can therefore expect a great potential from MIMO OFCDM systems. Recently, many studies have been carried out for OFCDM systems on how to gain frequency domain diversity and on the effect of multi-code interference (MCI) on achieving this diversity. In this paper first we study about the 2D-OVSF OFCDM system and in next section we discuses on multi symbol technique for efficient OFCDM system which show that by using 4-OVSF code in MIMO-OFCDM system decreases in bit error rate with increase in system throughput and capacity in detail and also showing the mat lab simulation result for the same.

## II. OFCDM SYSTEM

### A. 2D-VSF-OFCDM Transmitter

Fig. 1 shows the block diagram of the OFCDM system. It is similar to an OFDM system with the addition of 2D spreading block and code multiplexer. At the transmitter, the information bits are converted from serial-to-parallel into multiple streams equivalent to the number of code channels. Encoder add redundant bit and detect error. Each channel processor then modulates interleaves and carries out 2D spreading on the data bits. 2D spreading of 1D OVSF codes tree is illustrated diagrammatically in Fig. 2. As shown, the symbol is first spread by a time domain spreading code with spreading factor (SF) = NT (here NT = 4). This time spread signal is then duplicated on frequency interleaved subcarriers to prevent burst errors. The number of duplicate copies is same as the frequency domain SF = NF (here NF = 2). The signal obtained after duplication is then multiplied with the frequency domain spreading code. Similarly, 2D spreading is carried out for each symbol. If there are NC subcarriers being used then at any time instant, K1 = NC/NF symbols can be transmitted at a time on one code channel. K be the number of actually transmitted groups Each group of NB symbols will be spread with a unique code NB . Maximum K × NB user can access the system at the same time. This scheme is replicated for all code channels which are assigned individual time and frequency spreading codes to maintain the orthogonality among each other. The processed data is then multiplexed at the code multiplexer. In addition to information bits, pilot symbols are also multiplexed for channel estimation. Pilot symbols may be time, frequency or code multiplexed. Code multiplexed scheme provides more flexibility in design. To increase data rate a multicode transmission technique can be used. To maintain the orthogonality between pilot and data channels in frequency selective channels, pilot data is spread only in the time domain. To make synchronous operation of transmitter scrambler is used. Inverse fast fourier transform is used for conversion of data at transmitter from frequency domain to time domain. Cyclic prefix insertion maintains orthogonality between subcarrier, it gives extension to signal and make symbol periodic longer. Allow to signal to be decoded even if the packet is detected after some delay. Pulse shaping filter is used at transmitter to reduced inter symbol interference. Then broadcast the data.

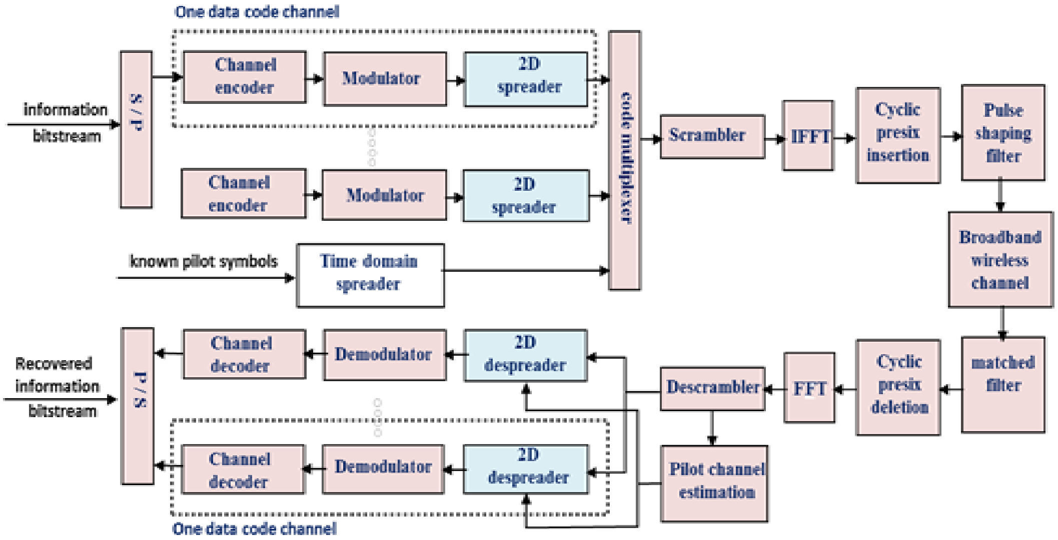

Fig.1 OFCDM system

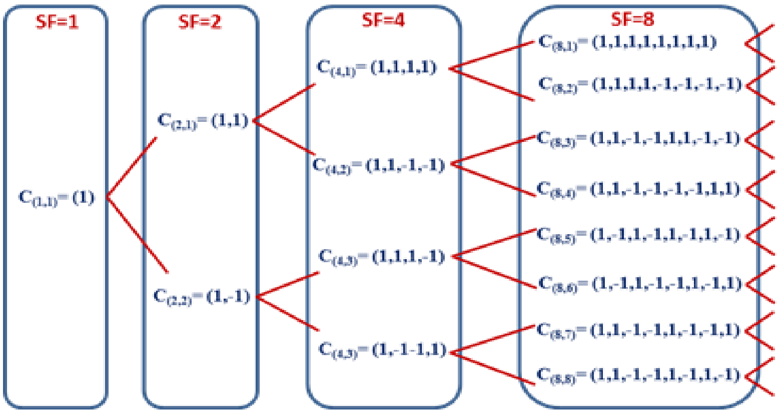

Fig.2 1D OVSF Codes tree

### B. 2D-VSF-OFCDM Receiver

In the receiver section, Matched filter is important to filter out what signal reflections do occurs in the transmission process. The cyclic prefix is removed in the received section, the resultant signal is descrambler and down converter by

(FFT) fast fourier transform. To make synchronous operation of receiver descrambler is used .The output of the descrambler is given to the two dimensional despreader and decoded as well as demodulated by the code channel and again parallel to serial conversion is done and recover the original signal.Despreading of 1D OVSF code is exact opposite process to spreading that occur at transmitter with the additional of two Different user data is spread with different frequency domain spreading code and same time domain spreading code MCI generated (K>NT). K ≤ NT, data symbol transmitted by the same NF carriers are spread with same frequency domain spreading code but different time domain spreading code .No MCI will present. It is preferred to assign code with greater code distance among adjacent code channels [(SF1/2)+1-dmin].Here dmin- the minimum length of strings of consecutive 1s or –1s in the element wise code product. Fig.3 show spreading of 1D OVSF code at transmitter and Fig.4 and 5 shows despreading of 1D OVSF code at receiver. The de-spreader employs simple EGC combining to collect spread signals. Finally, the de-spread bits are de-interleaved to obtain a serial data stream. This data stream is de-modulated to obtain the received data.

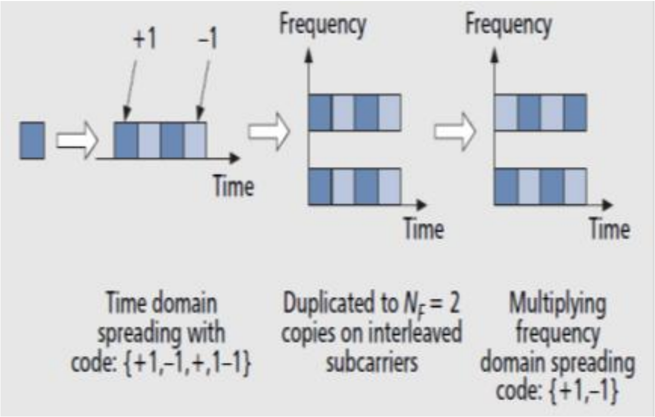

Fig.3 2D spreading with 1D OVSF code

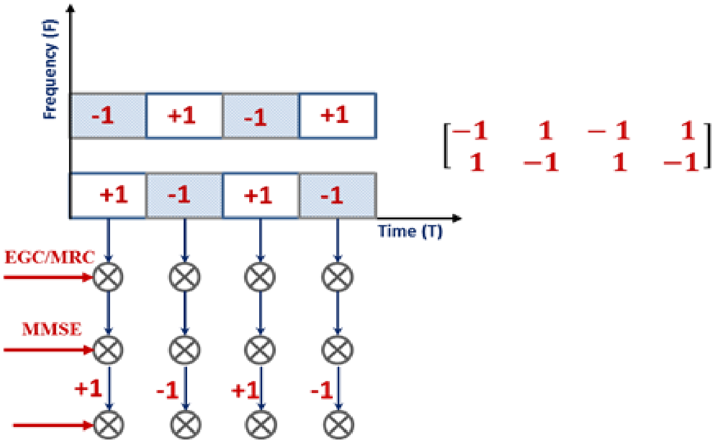

Fig.4 Despreading

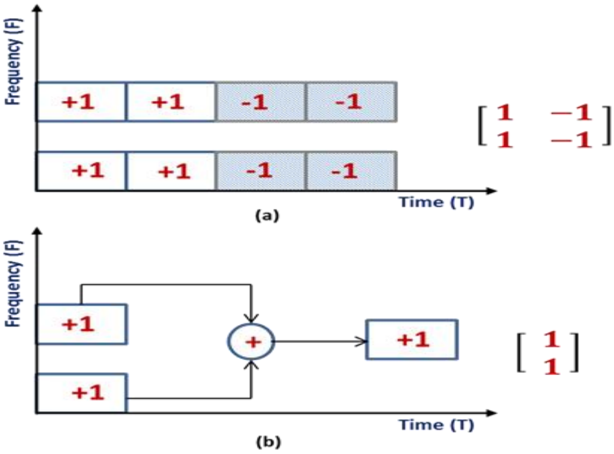

Fig.5 (a) Combing and (b) De-interleaving and combining

## III. 2D-SPREADING OF OFCDM SYSTEM WITH 2D OVSF CODES

Figure 6 shows the spreading of 2D OVSF codes spreading on both time and frequency domain. Using the orthogonality property between the 2-D codes, the orthogonal frequency coded division multiplexing (OFCDM) is performed in the downlink for mobile communication systems. The constructions of 2D OVSF codes are based on a recursive algorithm.2D OVSF codes use a seed matrix which represents its first layer. In addition, it uses two 2 × 2 orthogonal matrices to obtain the second layer. This process is repeated recursively to obtain codes with the required length. The system performance was tested and compared with previous OFCDM systems using 1D OVSF codes because of the better correlation properties of the 2D OVSF codes in comparison with 1D OVSF codes an improvement in system performance of OFCDM with 2D OVSF codes is observed.A decrease in BER and increase in throughput have been achieved that increase system performance.

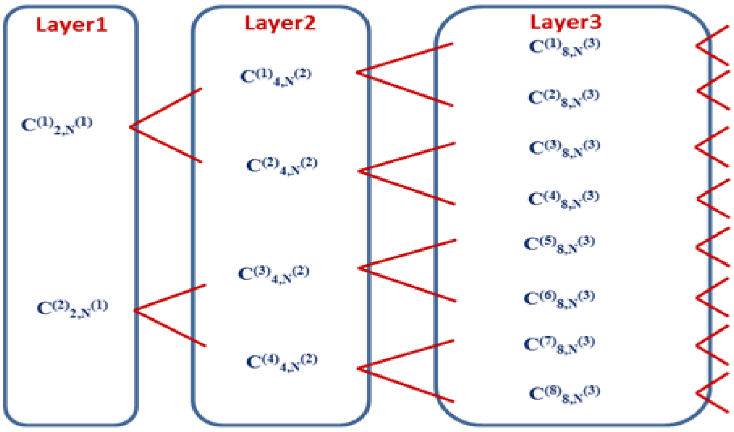

Fig.6 2D OVSF Codes tree

## IV. 2D-SPREADING OF OFCDM SYSTEM WITH 4D OVSF CODES

Code multiplexing and 2D spreading in the OFCDM system described in Section is achieved by using 1D OVSF codes and 2D OVSF codes .1D OVSF codes and 2D OVSF codes tree structures are shown in Figs. The construction of 4D OVSF codes is based on a recursive algorithm.4D OVSF codes use a seed matrix which represents its first layer. In addition, it uses two 4 × 4 orthogonal matrices to obtain the second layer. This process is repeated recursively to obtain codes with the required length. The input data stream is sent over various code channels. Each code channel first modulates the data which is followed by a serial-to-parallel conversion. This gives a K × SF1 matrix of modulated data. Here K = NC/NF is the number of parallel streams processed by each channel processor. NC is the number of subcarriers. In each stream, SF1 bits are simultaneously spread by K different 2D spreaders.SF1 bits are spread by a 4D OVSF code square matrix of SF1 dimension, here NT = 16; NF = 8, SF1 =4. Such that the 1st bit is spread by first row, 2nd bit by second row 3st bit is spread by third row, 4nd bit by fourth row and so on till the (SF1)th bit is spread by the last row of the matrix. The obtained matrix is then duplicated in the time domain. This gives a matrix of (K × SF1) × NF dimension. Second spreading: This is carried out by taking the Kronecker tensor product of the duplicated matrix with the frequency domain spreading code matrix of NF×NF dimension. Such that the jth symbol is multiplied with the jth row of the code matrix.

At the receiver, the serial data is converted to parallel form followed by cyclic prefix removal. This gives a matrix with NC rows and NT columns. FFT is performed on this matrix to demodulate the data. The demodulated data needs to be de-spread in accordance with the 2D spreading that was carried out at the transmitter with an aim to remove MCI caused because of code multiplexing of channels. first de-spreading is carried out using the code set with SF = SF2. Here, the de-spreader employs either simple equal gain combining (EGC) or maximal ratio combining (MRC) combining to collect spread signals.EGC combining is suitable for modulation techniques such as binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK). However, higher modulation schemes require MRC combining. the second de-spreading. The code set has SF = SF1. Here, the de-spreader employs simple EGC combining to collect spread signals. Finally, the de-spread bits are de-interleaved to obtain a serial data stream. This data stream is de-modulated to obtain the received data. Figure 7 shows the 2D spreading of 4D OVSF codes tree. In this OFCDM system we transmit 4 continues symbol from one data code channel other 4 symbol from other data code channel and this 4 symbol 2D spread at time by using our spreading method.

## V. SIMULATION RESULT

Figs. 8 and 9 show the obtained computer simulated results. Fig. 8 compares the performance of the OFCDM system using 1D OVSF codes against OFCDM system using 2D OVSF codes for achieving 2D spreading. The results are obtained by keeping a fixed SF = NT × NF, where NT = 8,NF = 4. One code channel is assigned for pilot data while the rest (NT − 1) × NF channels are fully loaded with information bits. The system performance was tested and compared with previous OFCDM systems using 1D OVSF codes because of the better correlation properties of the 2D OVSF codes in comparison with 1D OVSF codes an improvement in system performance of OFCDM with 2D OVSF codes is observed. The total number of code channels is kept equal to the SF = NT × NF. This helps to achieve the same data rate as an OFDM system.

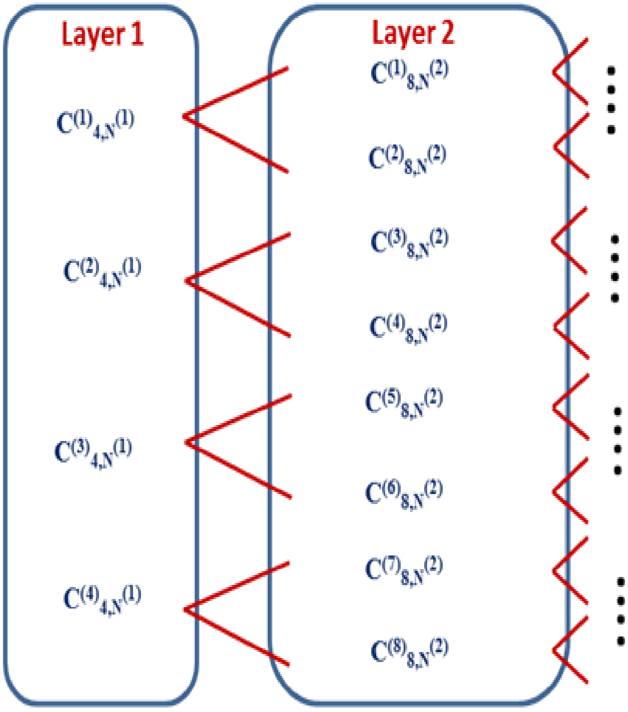

Fig.7 4D OVSF Code Tree

As can be seen in figure 9, the proposed OFCDM system with 4D code gives improved results with respect to the OFCDM system employing 1D and 2D OVSF codes. The system performance was tested and compared. In comparison with 1D OVSF codes and 2D OVSF codes an improvement in system performance of MIMO-OFCDM system with 4D OVSF codes is observed. A decrease in BER and increase in throughput by using 4D OVSF codes that make OFCDM system more efficient. Percentage of decreased in BER in OFCDM system with 4D OVSF code is 38.180 as compare to OFCDM system with 2D OVSF code and  Percentage of decreased in BER in OFCDM system with 4D OVSF code is 70.4460 as compare to OFCDM system with 1D OVSF code.

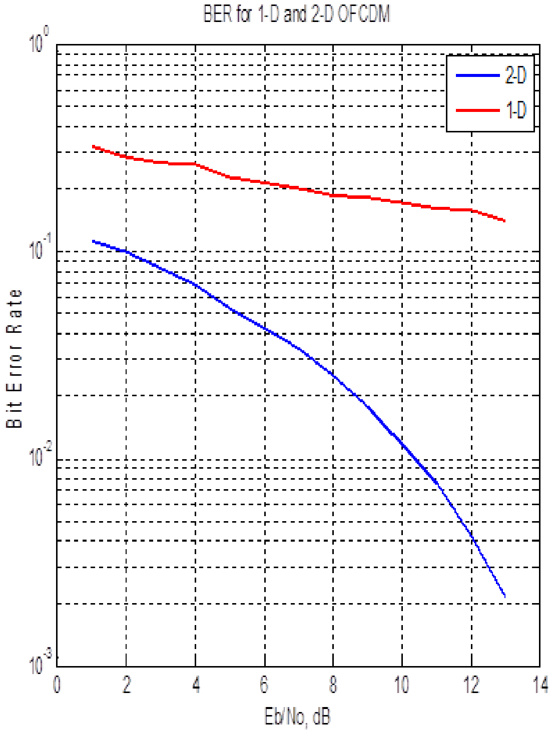

Fig.8 System performance curves using 1D OVSF and 2D OVSF codes

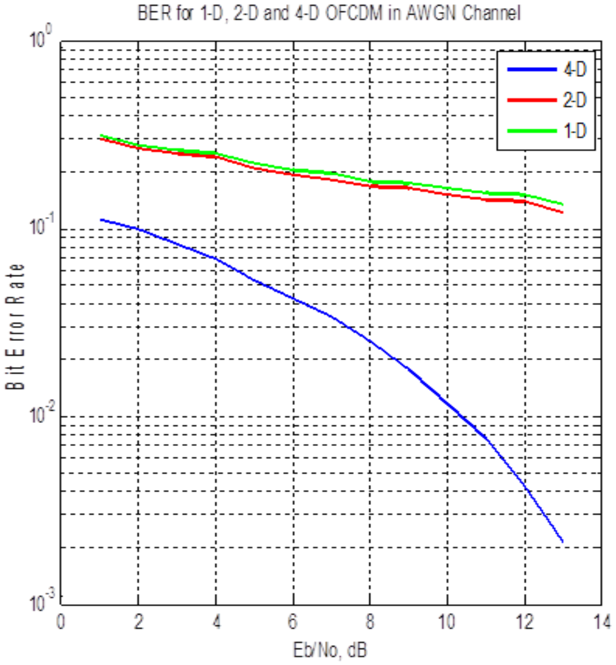

Fig.9 System performance curves using 1D OVSF, 2D OVSF codes and 4D OVSF codes

## VI. CONCLUSION

Our simulation results show that for 2 transmitters and 2 receivers the effect of AWGN channel on MIMO OFCDM system with 1D OVSF codes and 2D OVSF codes and 4D OVSF codes in which the SNR is varied from 0 to 25 db. The corresponding BER is plotted, that shows that the BER is lowest for highest value of SNR. A decrease in BER and increase in throughput have been achieved that increase MIMO OFCDM system performance with 4D OVSF code in AWGN channel as compare to 1D and 2D OVSF code in 4G. As a part of the future work we observe the result for nth OVSF code and research for MMSE detector for more MCI cancelation.

## VII. ACKNOWLEDGMENT

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