Different Channel coding techniques in MIMO-OFDM

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Abstract: *This Paper is containing the different types of Channel Coding which is used in multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM). To increase the efficiency of MIMO-OFDM there are several channel coding are applied in it.in this paper the aim is to show the discussion about all channel coding which are used as well as using in MIMO-OFDM system. This paper is structured in such way that in section I OFDM System and channel coding is described, in II section there is discussion about block diagram.In III section there is discussion of formula used in FFT and IFFT. In section IV several channel coding are defined which are used in MIMO-OFDM system. Further conclusion is made in section V.*

Keywords: *Convolutional Code, FFT, IFFT, MIMO, RS code, SISO, TBC.*

I. Introduction

OFDM is a special type of Frequency Division Multiplexing technique in which carrier is divided in to several subcarriers in equal part and each subcarriers are orthogonal to each other i.e. dot product of two consecutive subcarrier is zero. If the subcarrier are divided in sequence $C_1,C_2,C_3,C_4,C_5,\ldots\ldots$ up to n^{th} term i.e. C_n then they are orthogonal to each other in such a way it will satisfy the formula $C_n = n*C_1$, where $C_1$is first subcarrier [1]. MIMO stands for multiple input and multiple outputs which have advantage of spatial diversity i.e. obtained by spatial separation. By taking the subcarrier spacing equal to inverse of the symbol period and as subcarriers are orthogonal to each other hence the spectrum of each subcarriers has nothing or null at the center frequency of each of other subcarriers .the result of this will there is no interference between the subcarrier and allowing them to space as close as possible [2].Channel coding is used in Communication System to make system reliable for data transmission. In this there is two term encoder and decoder. Encoder is used for mapping of information to make suitable data transmission over a channel by adding extra bits with information and decoder is used to extract out the errors from the information of transmission side which comes through the channel at receiver side. There are many Channel coding techniques which are applied and applying now a days in MIMO-OFDM system they are –Convolutional coding and its various type [3], [4], [5], [8], Reed Solomon coding [6], [7], Turbo codes [9], [10], [11], [14]. Further about the new channel scheme that is known as Walsh sequence based channel coding [12], [13].

II. System Description

Figure 1 is showing the whole description of OFDM system .first of all there is an information bit source now it goes to encoder, Encoder is used for mapping of information to make suitable data transmission over a channel by adding extra bits with information further signal moves to interleaver, interleaving is a process by which there heaving a more robust nature of forward error correcting code with respect to the burst error. It takes symbols from data as input and produces an identical symbol at the output [16]. Further signal moves to the modulator. Modulation is a technique by which there is variation of one or more properties of a periodic signal called as carrier signal which is generally high frequency signal with a modulating signal that have information to be transmitted.

Now signal is going from serial to parallel converter by which signal get divided in to several subcarriers further those subcarrier is passed by Inverse Fourier Transform. It converts the signal from frequency domain to time domain. Afterthat it then converted into parallel to serial converter to move signal further now there is addition of Guard interval, Guard intervals are used to ensure that there is no interference between distinct transmission with each other. The purpose is to give the immunity to the propagation delays and echoes. Further signal moves to digital to analog converter because in space analog signal can travel. Further it connected with antenna which propagate the signal in to the space through which receiver can receive the signal.
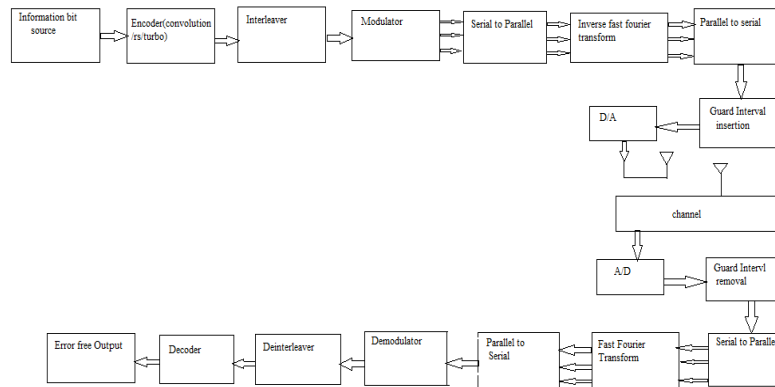
Fig1-Transceiver diagram of OFDM

At, receiver side when transmitted signal is caught by channel then then it goes to digital to analog converter. It convert analog signal in to digital signal. Further guard interval get removed from the signal and signal goes to serial to parallel and get through FFT [15]. FFT converts the time domain signal to frequency domain signal. After conversion of signal it carried to parallel to serial converter and then pass though demodulator. After that error from signal is extracted out by deinterleaver and decoder and get the error free output signal.

III.   Formula For FFT and IFFT

For FFT-

$$X(n) = \sum_{k=0}^{N-1} x[k]e^{-j\pi kn/N}$$

For IFFT-

$$x(k) = 1/N \sum_{k=0}^{N-1} X[n]e^{j\pi kn/N}$$

Where n is number of harmonics, N is the period of the signal, k is the time index and n/N is the nth harmonic. First formula converting the signal from time domain to frequency domain and second formula is converting the signal to frequency domain to time domain.

IV.   Channel Coding Techniques

1.Convolutional Coding-
Convolutional coding technique implies various types of category. Orthogonal convolutional coding, Super orthogonal convolutional coding, Standard convolutional coding, Punctured convolutional coding [3] are the basic categories of Convolutional coding which generally applied on MIMO-OFDM. Encoder consist of two shift registers whose length is K in which parallel output of the first shift register are connected to second with a connecting block. Second shift register is heaving modulo 2 adder and the coder output formed by this shift register. The relationship between code rate R and constraint length K is such that they satisfies the formula $R=1/2^K$. Figure 2is showing K=3, R=1/8 coder.
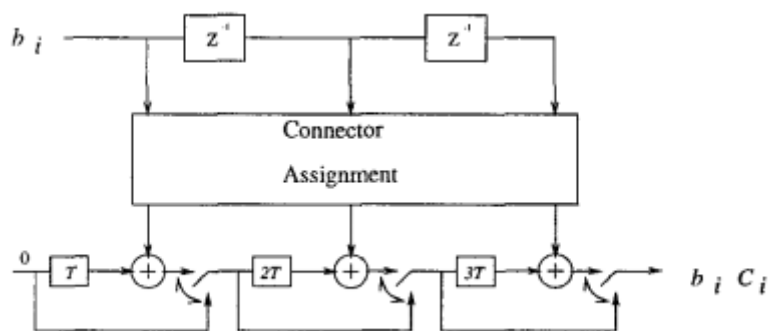
Fig.2 Orthogonal convolutional Encoder

Now super Orthogonal ender is an extension of the Orthogonal Encoder in Which R and K are such that they satisfies the formula $R=1/2^{K-2}$.At K=7 and K=3 the standard channel coding of code rate ½ is generally used. Punctured Convolutional coding is modified version of standard convolutional coding in which bits of output encoder are seriously deleted, generating a higher code rate.

Further there are different types of convolutional coding also available for Double data stream of MIMO system. These are as follows [4], [5].

Case1: Cross Antenna Convolutional coding with Per-antenna interleaving.
Case2: Per-antenna Convolutional coding with Cross antenna interleaving.
Case3: Cross Antenna Convolutional coding with Cross antenna interleaving.
Case4: Per-antenna Convolutional coding with Per-Antenna interleaving.

2.Reed Solomon Coding-

For MIMO-OFDM there is use of an RS code over a Galois field $F_2{}^m$ with maximum code length N= 2^m-1[ ]. Reed Solomon Code meets the singleton bound on the minimum distance of the code which satisfies the inequality d_{min}=N-k+1. If GF (q) is a finite field heaving q elements and it generates a code c which is rather specific BCH code over field GF (q) heaving length n is called reed Solomon code [6]. If α is primitive element and code heaving length of n=q-1. Now taking the dimension d such that it satisfies the equation 1<=d<=n. then generator polynomial g(x) is given as g(x)=(x-α) $(x-α^2)$ $(x-α^3)$………$(x-α^{d-1})$.according to Trappe and Washington (2006) reed Solomon code is a cyclic code in which code words are corresponding to the the polynomials, where every function f(x) is a polynomial with heaving its coefficient in gf (q) which cannot further factorized in to lower degree polynomials and assumption is that highest coefficient is 1 and it satisfies the equality-g (x) * f(x) with deg(f)<=n-d it hence follows that the there are q choice are available for every (n-d+1) coefficient of function f(x),and hence there are q^{n-d+1} code word are present in code c. hence it is concluded that reed Solomon code is MDS code since it makes a bound of singleton type [7].

3.Turbo coding-

In turbo coding there is use of two convolutional code in parallel having interleaver between them.This type of coding technique (using convolutional code an interleaver was firstly discovered by C. Berrou, A. Glavieux and P. Thitimajshima in 1993 IEEE conference proceeding. In turbo code we assume that data is configured in finite blocks which corresponds to the size of interleaver[9].

First of all convolutional code is converted in to the recursive symmetric convolutional codes.because this exhibits the better performance at low SNR. The figure for turbo encoder is given below.
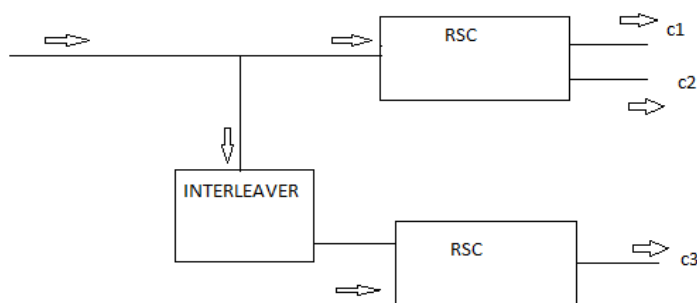

Fig 3.Turbo Encoder

For decoding there is two decoder which can be soft input soft output decoder separated by deinterleaver and process is base on soft input viterbi algorithm [8].to reduce or prevent the very high complexity of algorithm ,we can employ the chase algorithm[14] or these codes are decoded by exchanging soft information between the component decoders iteratively. Some component decoders are capable of generating soft information [9]. If the component decoder generates only hard output, we can exploits the trellis based decoding of the block codes to have soft output [10].

V. Conclusion

This review paper contains the information about different channel coding techniques which is generally applied in multiple input multiple output orthogonal frequency division multiplexing. There is introduction of Convolutional coding, Reed Solomon coding and Turbo coding techniques.to enhance the performance of MIMO-OFDM there are several researches is happening regarding Channel coding. Channel coding scheme based on Walsh sequence is also came in picture recently to enhance the performance of MIMO-OFDM [12]. The ongoing research in channel coding is Walsh Block Code which is based on Walsh sequence and VBLAST algorithm [13].

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