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Efficient Error Detection and Correction Algorithm In OFDM Communication

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***Abstract*—OFDM is one of the key transmission techniques in today's era of communication. Features like, safety and security enhance the efficiency of communication. Error Detection and Correction can improve the efficiency of such features. In proposed technique, Error Detection and Correction technique has been incorporated in OFDM to improve the safety and security of the communication. Using this method, BER (Bit Error Rate) of the OFDM signal has been compensated.**

Keywords—OFDM(Orthogonal Frequency Division Multiplexing); wireless communication; BER; Error Detection and Detection.

I. INTRODUCTION

During the past few years data rates demanded from fixed wireless networks increased from 1Mbps to 1Gbps and beyond. This increased data rate demand focused interest on modulation techniques that operate efficiently over broadband channels. Operation over broadband channels implies ability to operate even in fading channels in which significant multipath are present. Multicarrier modulation techniques, specifically Orthogonal Frequency Division Multiplexing (OFDM), are capable of operating with severe multipath, and can avoid ISI problems associated with Single Carrier modulation techniques. In communication system, secure and error free data transmission from transmitter to receiver is one of the major issues. And there are number of techniques for detection of error., one of the method is the use of parity bits. Parities are of the two types i.e., even and odd. In the even parity method, the value of bit is chosen so that the total number of 1's including parity bit is even in the transmitted signal. Similarly with odd parity, the total number of 1's must be odd.

II.OFDM

A. Need of OFDM in communication

OFDM is a widely used modulation and multiplexing technology, which has become the basis of many telecommunications standards including wireless area networks(LANs),digital terrestrial television(DTT) and digital radio broad casting in much of the world. The OFDM concept is based on spreading the data to be transferred over a large number of carriers, each being modulated at a low rate.

The carriers are made orthogonal to each other appropriately choosing the frequency spacing between them. Orthogonality gives the carriers a valid reason to be closely spaced with overlapping without inter-carrier interference (ICI).

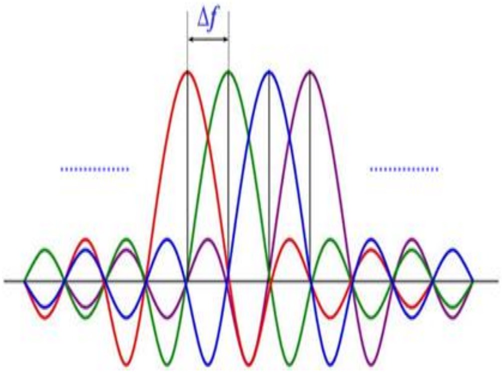


Figure 2.a.OFDM Signal

B.Why OFDM?

In contrast to conventional Frequency Division Multiplexing, the spectral overlapping among subcarriers are allowed in OFDM since orthogonality will ensure the subcarrier separation at the receiver, providing better spectral efficiency and the use of steep band pass filter was eliminated. OFDM system offers possibilities for alleviating many of the problems encountered with single carrier systems. It has the advantage of spreading out a frequency selective fade over many symbols. This effectively randomizes burst errors caused by fading or impulse interference so that instead of several adjacent symbols being completely destroyed; few symbols are only slightly distorted.

C. Basic OFDM system

In OFDM the entire bandwidth is divided into sub-channels or sub-carriers, these carriers are transmitted parallel to achieve high data rates, and to increase symbol duration and reduce ISI (Inter-symbol Interference).An OFDM signal is sum of all independent sub-carriers, modulated on to sub-channels of equal bandwidth. Figure 1.b. shows the block diagram of OFDM transmitter and receiver system.

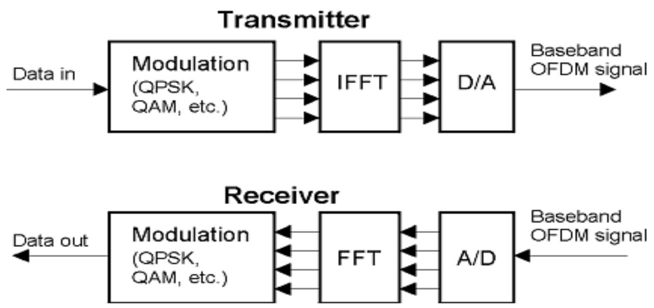


Figure 2.b OFDM transmitter and receiver system

D.OFDM system with the insertion of cyclic prefix

Figure 1.c depicts the overall modulation and demodulation techniques in OFDM system. One end of the transmitter, blocks of information carrying symbols are converted onto a N number of sub-streams using serial to parallel converter. Those streams can be modulated using an N number of orthogonal waveforms with frequency fk where k=0,……, N-1.This orthogonal waveform modulation is performed using an IFFT and a parallel to serial converter. The OFDM signal can be computed as the IFFT of the basic smallest elementary unit associated with different sub carriers. The output of the IFFT is considered as the sum of complex exponential functions known as basic functions, complex sinusoids, harmonics or the tones of multi tone signal.

After the converter the last L number of points can be appended to the beginning sequence as the CP (Cyclic Prefix).This CP is a special kind of spectral time guard in the symbol transitions. Finally the resulting samples are reshaped and transmitted. These transmitted blocks are then referred as a processed OFDM symbol.

Now the receiver can be able to do the reverse operation of transmitter, using a FFT operation. At this end sample signals are processed to find their origin point of a block and proper demodulation window.

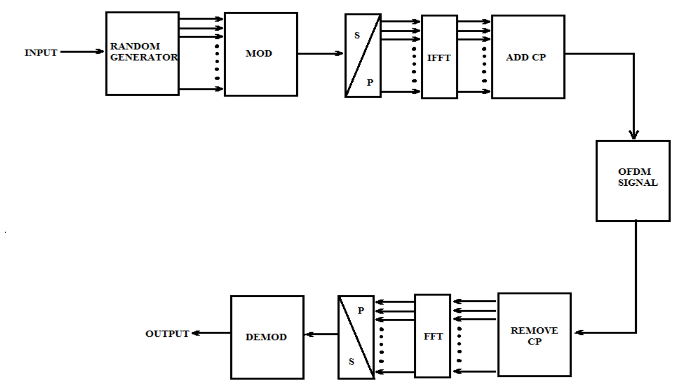


Fig 2.c. OFDM model

III.HAMMING CODE

A. Parity

Parity is a type of error detecting code that simply adds a bit and assumes either odd or even parity, depending on number of 1's in the sequence. For example an odd parity might replace the three-bit code words 001,101,100 and111 with the four-bit words 0001, 1101, 0100 and 0111.Any single transformation of a 0 to a 1 or a 1 to a 0 would change the parity of the block and make the error detectable. Additionally parity method allows only the detection of error. Table 3.a shows how to add parity bits to the given set of data.

7 bits of data	(count of 1 bits)	8 bits including parity	
		even	odd
0000000	0	00000000	00000001
1010001	3	10100011	10100010
1101001	4	11010010	11010011
1111111	7	11111111	11111110

Table 3.a

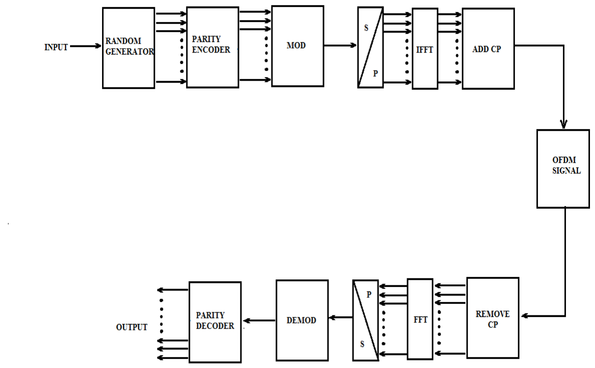


Fig 3.a OFDM communication using parity method.

original data	row parity bits	
1 1 0 0	1 1 0 0	0
1 0 1 1	1 0 1 1	1
0 1 1 1	0 1 1 1	1
0 1 0 1	0 1 0 1	0
	0 1 0 1 (col parity bits)	0 (matrix prity bit)

Table 3.b

Table 3.b shows the calculation of parity bits for a matrix.

B.HAMMING CODE FOR ERROR DETECTION AS WELL AS CORRECTION.

Hamming code is from the class of FEC (Forward Error Correction) codes. Hamming code is an improvement on the parity check method, which can correct one error at a price. It is very common for communication protocols to specify that a block of bits will be transmitted with a specific parity bit. If a block of data arrives at its intended destination with parity other than specified parity, it must be the case that at least one of the bits has been corrupted. A single parity bit is not sufficient to identify an even number of errored bits, nor is it sufficient to allow the receiver to correct errors. Hamming codes use multiple parity bits to allow for error correction.

Hamming is a well-known name in the field of encoding and decoding. Here we consider 256 bits of information to be transmitted over the channel.

For a (n, k) Hamming code, the values of n and k can be calculated using the following relationships.

For any value of (number of parity bits) m=>3, Hamming code (n, k) can be constructed using

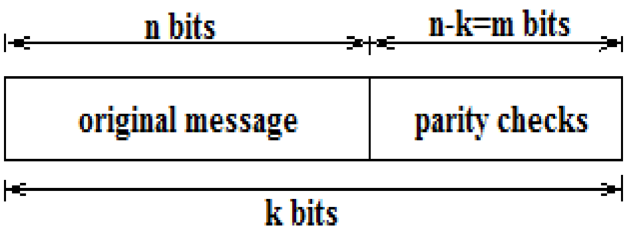
Message length $n=2^m-1$.

Code word length $k=2^m-m-1$.

Number of parity check bits $n-k=m$.

Minimum distance $d\ min=3$

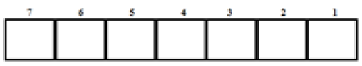
Considering (7,4) Hamming code, with a 4 bit data code and 3 bits of checking and adding bits to row vector



Hence we have 64(64*4=256) rows of 4 bit sets to be encoded with 3 parity bits for each row.

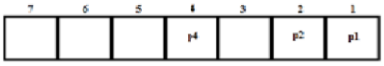
The following general algorithm is used for generating Hamming code

1. Number the bits starting from 1:1, 2, 3, 4...

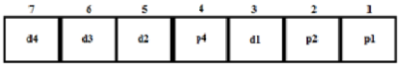


2. Write the bit numbers in binary form: 1,10,01,11…

3. All the bit positions that are powers of two are parity bits: 1, 2, 4, 8 …



4. All other bit positions are data bits.



5. Each data bit is included in a unique set of two or more parity bits, as determined by the binary form of its position.

   a. Parity bit 1 covers all bit position which has the least significant bit set: bit1 (the parity bit itself), 3,5,7,9…

   b. Parity bit 2 covers all bit positions which have the second least significant bit set: bit 2 (the parity itself) 3,6,7,10,11…

   c. Parity bit 3 covers all bit positions which have the third least significant bit set: bit 4 (the parity itself) 5,6,7,12,13,14,15,20…

   d. And similarly continue for next bit positions.

BIT POSITION		1	2	3	4	5	6	7
ENCODED DATA BITS		p1	p2	d1	p4	d2	d3	d4
PARITY BIT COVERAGE	p1	X		X		X		X
	p2		X	X			X	X
	p4				X	X	X	X

Table 3.c

Table 3.c shows the visualization of Hamming code.

The new row vector obtained will be=

| p3 p2 p1 d4 d3 d2 d1 |

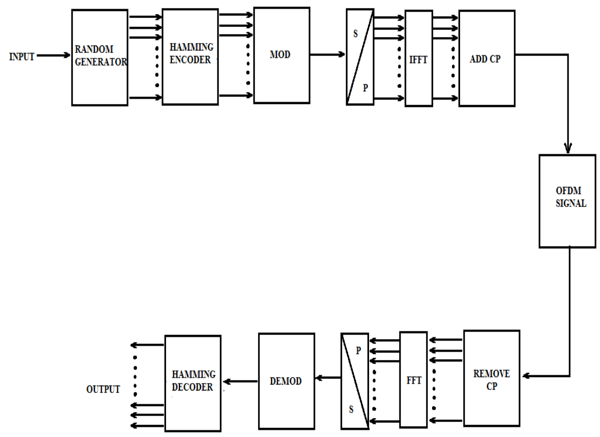


Fig 3.b OFDM Communication using Hamming Code

IV.IMPLEMENTATION

Developing a model of Hamming code using Matlab.

Specifications of the model

DATA FOR TRANSMISSION	256 BITS
BANDWIDTH	256bps
SUB-CARRIERS	4
CARRIER FREQUENCY	16 bps
BLOCK SIZE	16
SNR	30
MODULATION ORDER	128
NUMBER OF IFFT POINTS	16

Table 4.a

V. RESULT

Bit Error Rate (BER) is plotted for the developed model.

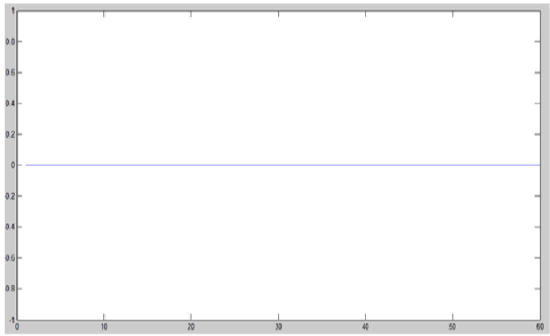


Fig 5.a BER plot

The BER is found to be zero.

VI.CONCLUSION

Thus we have tried to implement Hamming code using Matlab 7.10 to obtain lesser BER. Hamming codes have improved the way of communication by detecting and correcting errors.

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