International Journal of Advanced Technology in Engineering and Science
Vol. No. 11, Issue No. 12, December 2023
www.ijates.com
ijates
ISSN 2348 - 7550

Coded Orthogonal Frequency Division Multiplexing

Dr. Sunil U. Nyati
E&C KCE COEMJalgaon
nyatisir@gmail.com

Sejal R. Karwa
YCCE Nagpur
sejalkarwa2@gmail.com

Abstract

This article compares the performance of two modulation techniques—quadrature phase shift keying (QPSK) and M-ary quadrature amplitude modulation (M-QAM) with M=8, 16, 32, and 64 in a coded orthogonal frequency division multiplexing system. As an error-correcting code, convolutional technology is employed. A vehicular channel with additive white Gaussian noise (AWGN) is utilized for communication. According to simulation data, for QPSK and M-QAM, a coded orthogonal frequency division multiplexing system performs better than an uncoded one. Additionally, the system performs better with QPSK than it does with M-QAM. Additionally, when M rises, the performance declines.

Keywords: *COFDM, convolutional code, communication channel, cyclic prefix (cp).*

Introduction

As per the Orthogonal Frequency Division Multiplexing (OFDM) standard, a single high-information rate stream is divided into several lower rate streams that are simultaneously delivered across a number of smaller sub-channels.By carefully selecting subcarrier separating, such as by setting the subcarrier splitting to correspond to the valuable image time frame, it is possible to achieve orthogonality in OFDM. The range of each subcarrier has an invalid at themiddle repetition of each of the alternate subcarriers in the framework because the subcarriers are orthogonal.

Since it offers a significant reduction in balancing multi-sided quality compared to conventional correction processes, OFDM has gained more popularity in recent decades. Other interesting elements include combating inter-symbol interference (ISI) and inter-carrier interference (ICI), which causes the receiver's multifarious nature to decline. OFDM offers excellent phantom effectiveness, too. Additionally, OFDM is more resistant to recurrence- specific fading. Numerous recent published works have analyzed the OFDM system due to its exceptional benefits and broad uses [1–7].

A few obstacles exist for OFDM. The main disadvantage is that when the subcarriers are included intelligibly, anOFDM framework with a significant number of sub-carriers has a very high peak-to-average power ratio (PAPR). Furthermore, compared to single-carrier modulated systems, OFDM is more sensitive to Doppler spreading. Additionally, the transmitter and receiver oscillators' defects generate a stage commotion that affects how the framework operates.

The right frequency interleaving and coding are essential in order to take use of the respectable variation that multi-path fading provides. In most OFDM applications, coding thus becomes an integral component. Much study has focused on the appropriate encoder, decoder, and between leaver plan for data transmission using OFDM over fadingenvironments, as in references [8-9]

Despite the fact that a lot of research has focused on the development and use of coded OFDM frameworks for frequency specific fading channels, only a small number of studies provide useful performance analyses of these frameworks because of the unclear nature of this problem. In this case, a frequency-selective quasi-static fading channel is taken into account. This is a logical assumption for an indoor wireless environment that exhibits multi-pathfading but eventually exhibits mild alterations, characterized as semi-static. Contrary to coding in Additive White Gaussian Noise (AWGN) channels, where one dominant pair-wise error probability related to the minimum distanceof a block code or the free distance of a convolutional code determines the performance of the framework, all pair- wise error probabilities in a fading channel are equal. coded OFDM system decrease as banter polynomial of the signto-commotion proportion (SNR).Thus the strong association Cherno bound will be excessively free at any extent of SNR when the block length is enormous. Persuaded by the exhibition examination happens on block blurring directsin [10], the arbitrary coding maximum cutoff points [11] and the strong talk cut down limits [12] and moreover the possibility of flitting channel limit are completed for the presentation examination of coded OFDM structure.

COFDM System Model

The model of COFDM structure is showed up in Fig.1. It is for the most part involving transmitter, recipient, andchannel as a transmission way. These three areas are explained in focal points in resulting fragments [2].

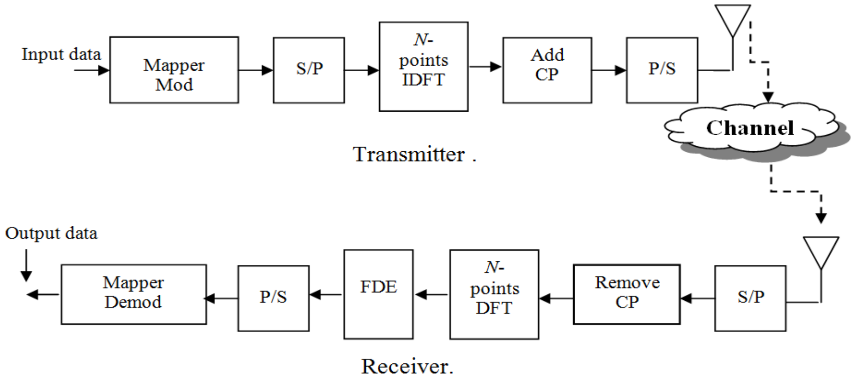


Fig.1 Model of COFDM system.

COFDM Transmitter

The multi-transporter transmitter involves a game plan of modulators, each with different transporter frequencies. The transmitter by then unites the modulator yields and makes the communicated banner. Expect that the N data to becommunicated are, k = 0, 1, . . . , N-1, where is an erratic number in a given quadrature sufficiency modulation(QAM)star grouping . Along these lines, the yield of tweak mapper takes any assessment of sixteen particular assessments ofQAM heavenly body showed up in Fig.2 [3], and [4].

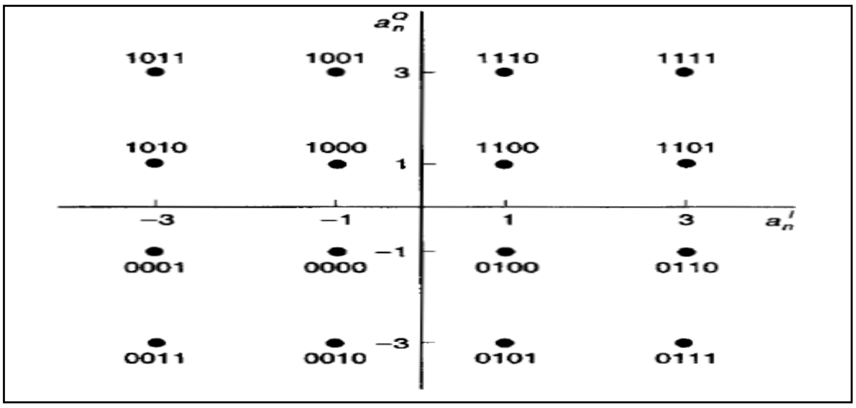


Fig.2 16-ary QAM constellation.

The yield from regulation mapper is associated with sequential to resemble (S/P) transformation. The S/P changes over sequential information into N equal streams. In light of the S/P change, the length of transmission timefor N images is connected with NTs..Letting t =n, where is the example stretch, the high level multi-transporter transmitter yield is,

$X(nT_S)=\sum^{N-1} x_k\, e^{j2\pi f_k nT_S}$ ------------1. $k=0$

Furthermore, if the carrier frequencies are uniformly spaced in the frequency domain by a frequency spacing of

f_S,=kf_S,k = 0, 1, . . ., N-1,then,

$X(nT_S)=\sum^{N-1} x_k\, e^{j2\pi k f_S nT_S}$------------2.

Equation (1) addresses the result of S/P transformation. Then, the equal information tests are taken care of to the reverse discrete Fourier change (IDFT) block to get the time space OFDM images.

Let f_S= 1/(NT_S) which is the minimum separation to keep orthogonality among signals on different modulators, then the OFDM signal is given by,

$X(n) =\sum^{N-1} x_k\, e^{j2\pi k(1/N)n}$-----------3.

The above recipe is the condition of a N-point IDFT. There are two copies of the got waveform, one on time and the other conceded by some time. ISI is provoked considering the way that the tail some piece of image 1 will intrudewith the treatment of image 2. To clear out ISI, a screen time span is for the most part implanted close to the beginningof each OFDM image [5], [6], and [7].

The cyclic prefix(CP) is a void ISI since it goes about as watch space between moderate images, it similarly change over the straight convolution with channel drive response into a cyclic convolution. As a cyclic convolution in the time space changes over into a scalar expansion in the repeat region, the subcarriers stay symmetrical. The CP is an exact of the last examples of the OFDM image into its front. Allow an opportunity to show the length of CP to the extent that samples, then the extended OFDM images currently have the range of Tsys= Tsub + TG

Fig.3 shows two nonstop OFDM images. The screen interval longer than the best deferral of the multipath channel (thinks about keeping up the symmetry among the subcarriers. As the soundness of each conceded subcarrier has been legitimate by the CP, its symmetry with all unique subcarriers is kept up got done. Exactly when the length of the safeguard interval (CP) is set more limited than the most outrageous delay of a multipath channel, the tail some part of an OFDM image impacts the head some piece of the accompanying image, achieving the ISI.

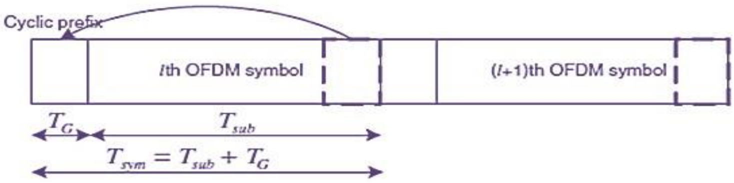


Fig.3 OFDM Symbols with CP.

The output equation of the CP block is (n)=$x((n-L))_N$, where n = 0, ……, N+L-1. Then the output from the CP block is applied to parallel to serial (P/S) conversion. The P/S converts parallel data into N serial streams [8], and[9].

Convolutional code

A convolutional code is a kind of blunder revising code that produces equality images through the sliding utilization of a boolean polynomial ability to an information stream. The sliding application addresses the convolutionof the encoder over the information, which offers climb to the term 'convolutional coding.' The sliding thought of theconvolutional codes energizes lattice unraveling using a period invariant lattice. Time invariant lattice translating licenses convolutional codes to be most outrageous likelihood fragile decision decoded with reasonable complexity.

The ability to perform moderate most outrageous greatest probability decision disentangling is one of the critical benefits of convolutional codes. This is rather than exemplary block codes, which are generally addressed by a period variation lattice and in this manner are typically hard-decision decoded. Convolutional codes are consistently depictedby the base code rate and the profundity (or memory) of the encoder [n,k,K]. The base code rate is usually given as n/k, where n is the information rate and k is the result image rate. The profundity is much of the time called the "imperative length" 'K', where the yield is a part of the current information and furthermore the previous K-1 data sources. The profundity may in like manner be given as the amount of memory parts 'v' in the polynomial or the bestpossible number of states of the encoder (generally 2^v) [9].

Convolutional codes are often portrayed as relentless. Anyway, it could moreover be said that convolutional codes have erratic block length, rather than being steady, since most certifiable convolutional encoding is performed on blocks of information. Convolutionally encoded block codes consistently use end. The inconsistent block length of convolutional codes can moreover be separated to extraordinary block codes, which generally have fixed block lengthsthat are directed by logarithmic properties.

The code pace of a convolutional code is for the most part changed through image penetrating. For example, a convolutional code with a 'mother' code rate n/k=1/2 may be penetrated to a higher pace of, for example, 7/8 essentiallyby not sending a piece of code images. The exhibition of a penetrated convolutional code overall scales well with the proportion of equality sent. The ability to perform saving fragile decision translating on convolutional codes, and what's more the block length and code rate versatility of convolutional codes, spreads the word about them very wellfor advanced correspondences [10].

Communication channel

To simplify the mathematical analysis, a time-invariant channel is assumed which has the following response with R taps,

$h^T = [h_0\ h_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots h_{R-1}\ ]$
……………………………………………………………………………………

The channel impulse response is circularly convolved with the transmitted signals owing to the CP in OFDM signals, so the output of the channel will be as follows,

$y(n)=h(n) * x(n) + N(n)$

$$y(n)=h(n) * x((n-L))_N + N(n)$$

$y(n)=h(n)x(n)+N(n)$

The output of the channel (i.e. the received signal) can be written in matrix form as follows [10]:

$$\begin{bmatrix} \overbrace{0 \ \cdots \ 0}^{N_g-R+1} & h_{R-1} & h_{R-2} & \cdots & h_0 & \overbrace{0 \qquad\qquad \cdots \ 0}^{N-1} \\ 0 \ \cdots \quad\ 0 & & h_{R-1} & h_{R-2} & \cdots \ h_0 & \cdots \ 0 \\ & & & & \cdots & \\ 0 & & & & \cdots & 0 \ h_{R-1} \ h_{R-2} \ \cdots \ h_0 \end{bmatrix}$$

Simulation Results

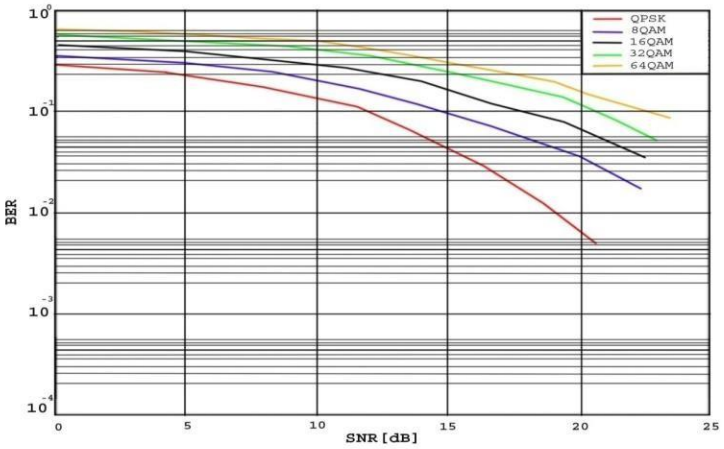
Maltlab 2022 is used to mimic the COFDM system, with modulation methods like QPSK, 8-QAM, 16-QAM, 32-QAM, and 64-QAM. Convolutional code is integrated with the model with the intention of enhancing the framework'sexecution; as a result, the OFDM is referred to as coded OFDM (COFDM). It is decided to use a convolutional code with an octal generating polynomial of length 7 (133,171). Vehicle channel with 11 ways is the channel display in use. Table 1 contains a list of the reproduction-related parameters.

TABLE 1. COFDM Simulation Parameters.

Parameter	Value
FFT Size	512
Cyclic Prefix Length	20Samples
Time between Samples	24.41 ns
Channel Coding	Convolution Code with Rate=1/2
Modulation Types	QPSK, 8-QAM, 16-QAM, 32-QAM, and 64-QAM
Channel Model	Vehicular Channel with 11Paths

Bit-error-rate (BER) vs signal-to-noise ratio (SNR) measurements are used to assess how well the overall system is working. The execution of the framework for an uncoded system is shown in Figures 4 and 5, respectively. It appears that a coded system performs better than an uncoded system. Additionally, QPSK performs better than M-QAM, andthe performance declines as M grows.

Fig.4 BER performance of un-coded OFDM.



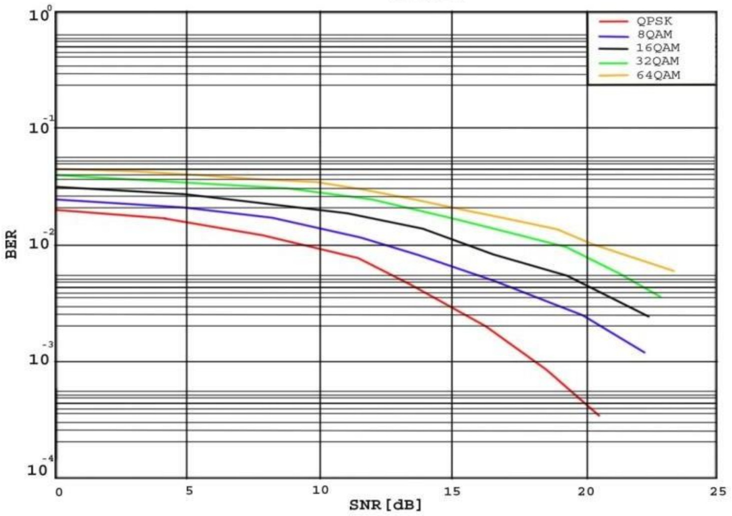


Fig.5 BER performance of un-coded OFDM .

Conclusion

To investigate the performance of the COFDM system over the vehicular channel with AWGN utilizing QPSK, 8-QAM, 16-QAM, 32-QAM, and 64-QAM, a model of the system was created. As an error-correcting code, convolutional technology was employed. The outcomes demonstrate that COFDM performs better than un-coded one.Additionally, QPSK offers superior performance than M-QAM. Additionally, the performance suffers as M increases

References

[1] J. Bingham, "Multicarrier Modulation for Data Transmission: An Idea Whose Time Has Come," IEEE Commun. Mag., vol. 2, no. 5, May, 2008, pp. 5–14.

[2] B. LeFloch, M. Alard, and C. Berrou "Coded Orthogonal Frequency Division Multiplex," Proc. IEEE, vol. 83, June, 2012, pp. 982–96.

[3] B. Stephen, "History of OFDM," IEEE Commun. Mag.,vol. 47, no. 11,Nov., 2012, pp. 26–35.

[4] V. Sharma, "BER performance of OFDM-BPSK,-QPSK,- QAM over AWGN channel using forward Error correcting code," International Journal of Engineering Research and Applications, vol. 2, issue 3, 2012, pp.1619-1624.

[5] Y. Khan, "To Improve Performance of OFDM System Using Optimize Adaptive Coding Technique with Convolutional and BCH Coding," International Journal of Application or Innovation in Engineering & Management, vol. 3, issue 5, May 2014.

[6] B. Alex,"Behavior and Techniques for Improving Performance of OFDM Systems for Wireless communications," International Journal of Advanced Research in Computer and Communication Engineering vol. 4, issue 1, January 2015.

[7] Sachin, "Analyzing the BER Performance of OFDM-System with QPSK and BPSK Modulation Technique," International Journal of Innovative Research in Advanced Engineering, vol. 2. no.6, 2018.

[8] B. Lu, X. Wang, and K. R. Narayanan, "LDPC-based space-time coded OFDMsystems over correlated fading channels: Performance analysis and receiver design," IEEE Trans. Wireless Commun., vol. 1, pp. 213-225, 2020.

[9] H. Kim, "Turbo coded orthogonal frequency division multiplexing for digitalaudio broadcasting," in 2020 IEEE Intern. Confer. on Commun., vol. 1, pp. 420-424.

[10] E. Malkamaki and H. Leib, " Coded diversity on block-fading channels," IEEE Trans. Inform. Theory, vol. 45, pp. 771-781, 2021.

[11] R. G. Gallager, Information Theory and Reliable communication. New York, Wiley, 2021.

[12] S. Arimoto, "On the converse to the coding theorem for discrete memoryless channels," IEEE Personal Commun., vol. IT-19, pp. 357-359, 2022.

[13] N Al-Awad, and M. Al-Rawi" On the Performance of COFDM System," International Journal of Open Information Technologies, vol.6, pp.39-42, 2022.

[14] M. Liu, W. Shen, J. Yan and H. Zeng, "A Simulation Method of Orthogonal Frequency Division Multiplexing," 14th International Conference on Computer Research and Development (ICCRD), Shenzhen, China,, pp. 388-393, 2023.