Journal of Innovative Research in Engineering Technology and Management Science
Volume 01, Issue 03, July 2025
www.jiretms.com

Concatenated LDPC-based STBC-OFDM System with MRC Receivers Performances

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To Cite this Article
Nivedita and Niharika, "Concatenated LDPC-based STBC-OFDM System with MRC Receivers Performances", Journal of Innovative Research in Engineering Technology and Management Science, Vol. 01, Issue 03, July 2025, pp:20-24.

***Abstract**: This paper analyses the reliability of a concatenated Space-Time Block Coding Orthogonal Frequency Division Multiplexing (STBC-OFDM) system implemented with Maximum Ratio Combining (MRC) receivers and Low-Density Parity-Check (LDPC) coded. The proposed system integrates spectrum efficiency of OFDM, spatial diversity of STBC and error-correcting properties of LDPC codes in order to enhance reliability of communication in fading channels. MRC receivers allow optimum combining of received signals on many antennas and thereby maximise signal-to-noise ratio. Compared with the traditional non-concatenated systems (and MRC systems), simulation results indicate significant improvements in bit error rate (BER) performance in a variety of channels. As per the research, the combined effects of LDPC coding, STBC, OFDM and MRC help in the successful reduction of multipath fading and noise effects and this makes the system best fit in high data rate wireless communications applications.*

***Keywords**: STBC, LDPC, AWGN, MRC, OFDM*

I. Introduction

Advanced wireless communication networks have high data throughput, reliability and efficient use of spectrum accessing, especially under multipath fading environments. Orthogonal frequency division multiplexing, or OFDM, is popular because of high spectral efficiency and frequency selective fading resistance. Space-Time Block Coding (STBC) can enhance the resilience and the dependability of a signal further by making use of spatial diversity across numerous antennas. Performance of error correction code near capacity in error avoidance and correction, e.g., Low-Density Parity-Check (LDPC) codes, is a well-known fact. LDPC coding-STBC-OFDM concatenations develop a powerful coded system that simultaneously exploits coded gain and spatial diversity. Moreover, signals in multiple antennas are used to maximise the quality of signal and minimise the number of mistakes in the Maximum Ratio Combining (MRC) receivers. This work studies the performance of a concatenated LDPC-based STBC-OFDM system with MRC receivers and proves its potential of reliable high-speed wireless communications as it focuses more on bit error rate (BER) and resilience of the system in fading channels.

II. Related Works

The process of combining LDPC codes and STBC-OFDM systems in an attempt to enhance the reliability of wireless interactions has already been well investigated in the past. Protocol analysis indicates that LDPC codes can significantly improve performance over bit error rate (BER) channels by highly effectual error correcting properties. It is evidenced that, when STBC is complemented with OFDM, the effects of multipath fading could be successfully reduced by appropriately exploiting spatial and frequency diversities. Even to enhance further signal quality and system performance has led to maximum ratio combine (MRC) receivers to combine multi antenna signals in the optimum manner. So as to simultaneously enjoy the advantages of coding and of diversity, recent work has focused on concatenating LDPC coding and STBC-OFDM, with significant performance gains obtained in terms of uncoded systems or singly coded systems. Nevertheless, the optimal delay and complexity maximisation is not easy, and this motivates further research regarding appropriate techniques to use decoding codes.

III. LDPC Code

Error-correcting codes that are constructed to be strong and with a sparse parity-check matrix with near-Shannon-limit performance are termed Low-Density Parity-Check (LDPC) codes. LDPC codes can provide great forward error correction in the concatenated LDPC-based STBC-OFDM system significantly reducing bit errors caused by fading and noise. Iterative decoding methods make it practical to detect or correct errors with controlled computational expense [1]. When used with OFDM and STBC, LDPC codes enhances resistance against frequency-selective fading and time-varying multipath fading on the system. Moreover, Maximum Ratio Combining (MRC) receivers are used to further optimize the effective signal-to-noise ratio before LDPC decoding and this adds an advantage to the system generally. Integration of LDPC coding in this system ensures a better bit error rate (BER) and great reliability, which qualifies the system to be used in high data rate communication in challenging channel conditions in wireless communication.

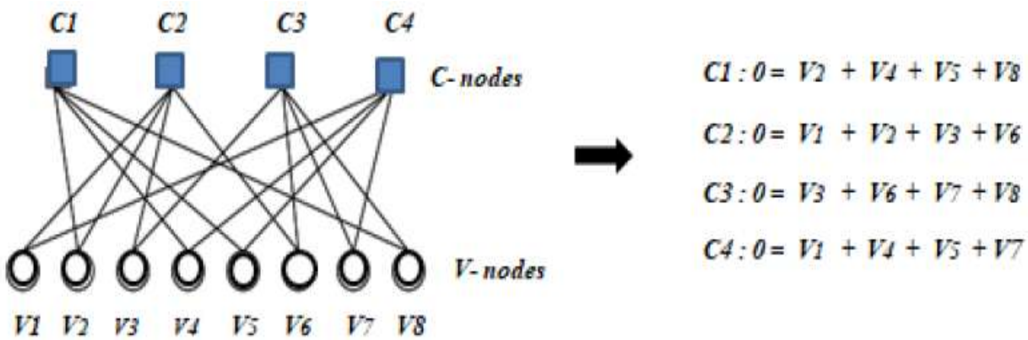

Fig 1: Tanner graph

IV. LDPC Coding Maximal Ratio Combiner

Low-Density Parity-Check (LDPC) codes are very efficient error-correcting codes with sparse parity-check matrices whose iterative decoding approach can approach capacity. The LDPC coding enhances error resistance in the wireless systems in fixing the errors due to the fading, noise, and interference. In a manner that weights the signal strength of each of the branches, together with the level of noise, the diversity strategy called Maximal Ratio Combining (MRC) would use the receiver to combine numerous antennas signals in the optimal manner possible. This increases the reliability of detection by maximising the gain of the total signal-to-noise ratio (SNR) [4-6].

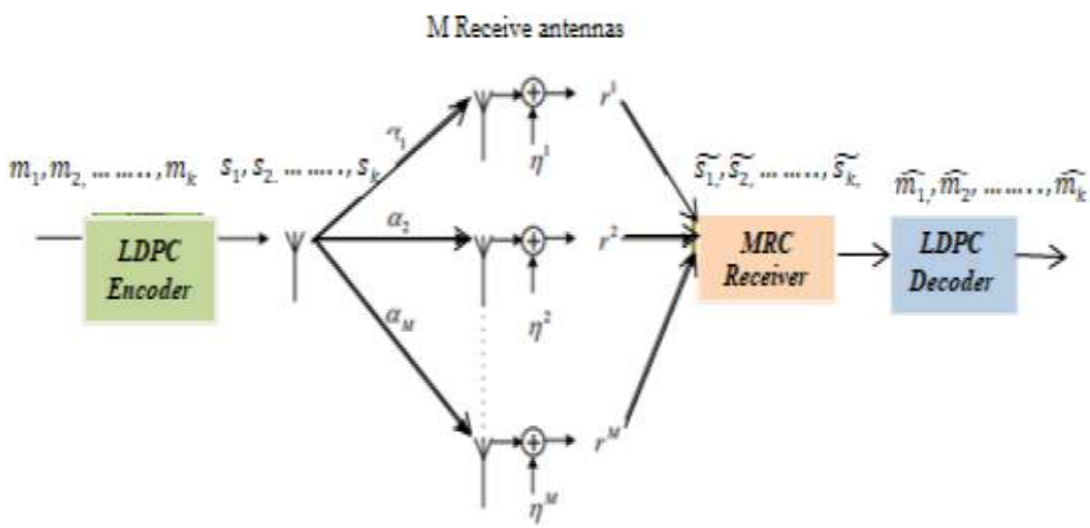

Fig 2: LDPC Code maximal ratio combiner

The implementation of LDPC coding together with an MRC receiver generates a synergistic effect: the LDPC coding will remove most residual error, whereas the MRC receiver will maximize the quality of the received signals by exploiting geographical diversity. A beneficial effect of this combination arises when there is a change in signal strength among antennas in fading environments. Using the MRC output as an input to the LDPC decoder greatly reduces errors per bit and allows more reliable decoding to be affected. MRC receivers and LDPC codes collaborate to provide a powerful solution to reliable high speed wireless applications.

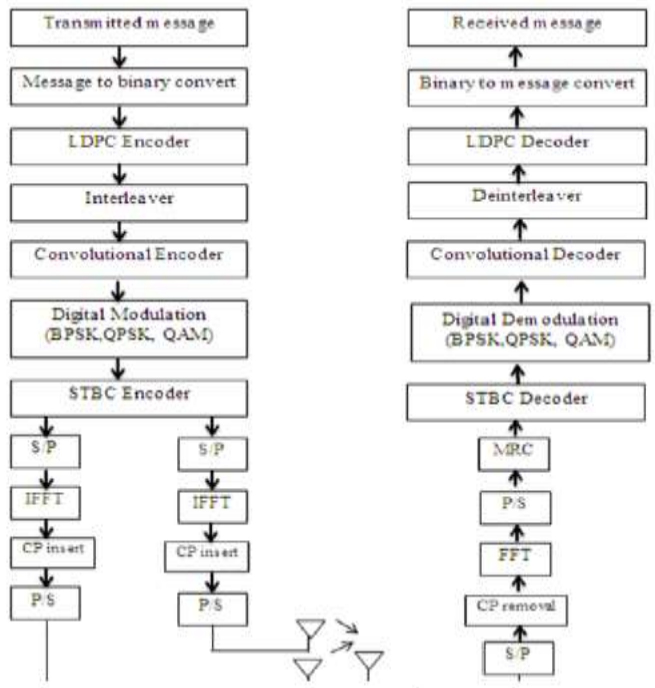

Fig 3: STBC-LDPC encoded block diagram

V. Simulation Results

Concatenated LDPC-based STBC-OFDM system with Maximum Ratio Combining (MRC) receivers has an enormous improvement of performance in the fading wireless channel case as revealed by simulation results. The curves reveal that the Bit Error Rate (BER) reduces significantly in comparison to classical OFDM that does not employ any coding or diversity methods [6]. By means of LDPC codes the system suffers through highly effective forward error correction that effectively eliminates noise and interference. STBC eradicates part of the effect of multipath fading because of the extra spatial diversity. MRC receivers critically enhance the performance by combining the data signals of multiple antennas in an optimal manner and optimising the signal-to-noise ratio before it can be decoded.

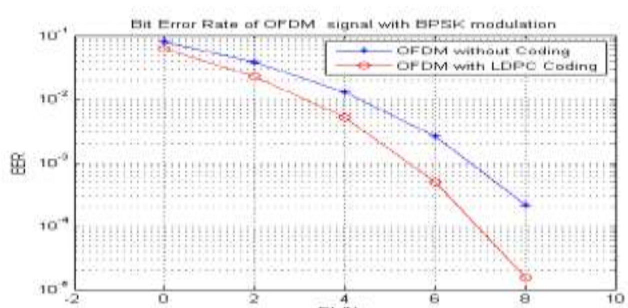

Fig 4: BER of OFDM coding

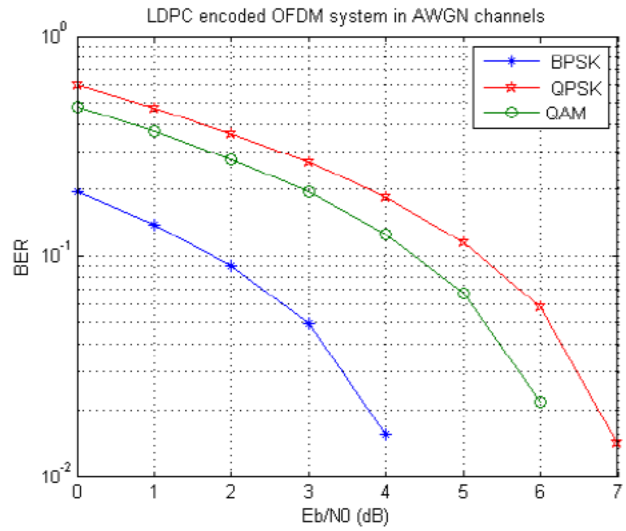

Fig 5: OFDM system in AWGN channel

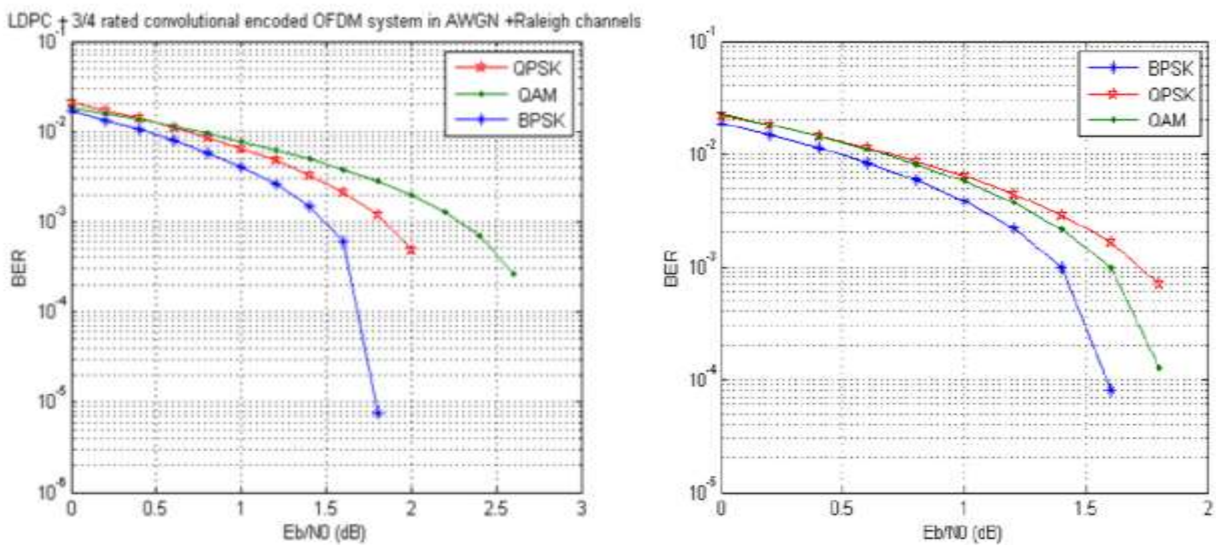

Fig 6: BER of the LDPC +3/4 Rayleigh channels

VI. Conclusion

The proposal of concatenated LDPC-based STBC-OFDM system employing Maximum Ratio receivers that mate with strong error correction, spatial diversity, and optimum signal combining have massive enhancement in terms of the wireless communication performance. To minimize the impacts of multipath fading, a series of STBC and MRC in combinatorics is intended to exploit transmit and receive diversity, whereas LDPC coding provides powerful error recovery properties close to channel capacity constraints. OFDM ensures that there are high data speed by effectively managing frequency-selective channels [2-4]. In the fading environment, the simulation performance indicates great performance improvements in terms of bit error rate (BER) which establishes reliability and effectiveness of the system. Such combined approach is a potential alternative to next generation wireless systems which require high through put and reliability notwithstanding the complexity of the implementation of such uses. It constitutes an important milestone in the quest of having more effective, stronger, and scalable wireless communication systems in a number of application scenarios [1].

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