# Various Diversity Combining Techniques with LDPC Codes in MIMO-OFDM

**Naveen Kumar[1], Arvinder Pal Singh Kalsi[2]**

[1]Student, School of Electronics and Communication, Lovely Professional University, Phagwara, Punjab, India

[2]Assistant Professor, Department of Electronics and Communication, Lovely Professional University, Phagwara, Punjab, India

**Abstract:** ***OFDM with MIMO is the most efficient and commonly used technology. In MIMO system multiple antennas arrays used across transmitter and receiver side. OFDM with MIMO technology provide reliable communication and efficient manner of signal reception across receiver. In MIMO technology Bit rate error very high due to Multi-path fading effect of channel. In this paper new technique is proposed to reduce Bit rate. The proposed technique uses LDPC filter with OFDM along diversity methods. LDPC filter is used in OFDM to reduce bit rate error and calculate performance in terms of BER for receive combing technique such as MRC. Since MRC provide excellent reduction in BER as compare to SC and EGC. The proposed technique is implemented in MATLAB and result shows that proposed technique will reduce bit rate error in MIMO-OFDM.***

**Keywords:** Orthogonal frequency division multiplexing (OFDM), multiple input multiple output (MIMO), Low density parity check (LDPC), maximal ration combining (MRC), equal gain combining (EGC), selection combining (SC).

## 1. Introduction

In the concept of OFDM is subset of frequency division multiplexing which is single channel utilizing multiple sub-carriers on adjacent frequencies. Sub carriers in OFDM system are overlapping to maximize spectral efficiency. Overlapping adjacent channels can interfere with one other. OFDM system is precisely orthogonal to one another. OFDM systems are able to maximize spectral efficiency without causing adjacent channel interference [6]. In the OFDM communication systems are able to more effectively utilize the frequency spectrum through overlapping sub-carriers. These sub-carriers are able to partially overlap without interfering with adjacent sub-carriers and maximum power of each sub carrier corresponds directly with the minimum power of each adjacent channel. Sub-carrier is represented by different peak. Peak of each subcarrier corresponds directly with the zero crossing of all channels. OFDM channels are different from band limited FDM channels how they apply shaping filter [7]. MIMO communication uses multiple antennas at both the transmitter and receiver to exploit the different domains for spatial multiplexing and spatial diversity. In the spatial multiplexing used to increase the capacity of MIMO link by transmitting independent data streams in the same time slot and frequency band simultaneously for each transmit antenna and differentiating multiple data streams at the receiver using channel information about each path propagation path.: MIMO in contrast to traditional systems takes advantage of multipath propagation signals. Rather to apply different techniques to handle with multipath signals MIMO puts multipath signals to work. This is done by sending and receiving more than one data signal in the same frequency band at the same time by using multiple transmit and receive antennas [8]. Wireless channels are multipath fading channels, causing ISI (Inter symbol interference), ISI occurs when a transmission interferes with itself and receiver cannot decode the signal correctly.

For multipath signals travelling through different paths have their independent effect imposed by the channel. Signal parameters on which multipath channel have effect are independent path gain (or loss), independent path frequency offset, independent path phase shift (change in angle), independent path time delay. To remove ISI from the signal, many kinds of equalizers can be used. Different techniques are used to handle the changes made by the channel; receiver requires knowledge over CIR (Channel Impulse Response) to combat with the received signal for recovering the transmitted signal. CIR is provided by the separate channel estimator. Usually channel estimation is based on the known sequence of bits, which is unique for a certain transmitter and is repeated in every transmission burst. Which enables the channel estimator to estimate CIR for each burst separately by using the known transmitted signal and the corresponding received signal. LDPC are the codes which are used in channel coding for the different enhancement in the system performance. We are trying LDPC channel coding with BPSK modulation scheme with MRC and EGC at the receiver over Rayleigh fading channel. BER Performance of System is analyzed with and without LDPC channels coding.

## 2. Literature Review

Satoshi Gounai et al. [1], find result that the SNR thresholds of a regular LDPC codes and the irregular LDPC codes and optimum degree distributions of the irregular LDPC codes for SIMO systems with several diversity orders.

Eric Villier [2], derived the performance of optimum combining in the presence of multiple equal power interferers and noise when there is less no. of the interferers than the number of antenna elements. We have desired signal and interferers which use flat Rayleigh fading and there are propagation channels which are independent. The probability density function (PDF) of the output signal-to-interference-plus-noise ratio (SINR), cumulative distribution function (CDF) of the SINR and the bit-error rate (BER) of some binary modulations has been derived using the Rayleigh fading.

Mackey et al. [3], proposed that the most powerful error correcting codes LDPC is based on very sparse matrices that give better results than the turbo codes. These results using LDPC codes give results close to Shannon capacity for binary- symmetric channel and symmetric stationary ergodic noise.

Brennan [4], In This Paper they have used three types of diversity techniques Selection Diversity, Maximal ratio combining, and Equal Gain Combining System. In This Paper we have find out the quantative measurement of their performances. We used Rayleigh fading in these diversity techniques. We find out that equal gain combines system will give performances essentially equivalent to the maximum obtainable from any other system like maximal ratio combining etc. The principal application of the results is to diversity communication systems and the discussion is set in that context, but many of the results are also applicable to certain radar and navigation systems.

Mohamed-Slim Alouini [5], In this Paper They find a performance analysis of two hybrid selective combining/ maximal ratio combining (SC/MRC) diversity receivers over Nakagami-m fading channels with a flat multipath intensity profile is present. Hence numerically compared the conventional SC and MRC schemes. Numerical results for particular cases of interest show that the bit error rate (BER) degradation arising from the use of hybrid SC/MRC instead of MRC is independent of the average signal-to-noise ratio (SNR) regardless of the severity of the fading and that MRC provides a higher rate of improvement than the hybrid SC/MRC as the severity of fading decreases.

## 3. Spatial Diversity

In Spatial diversity, there are multiple receiving antennas placed at different spatial locations, resulting in different (possibly independent) received signals at different times due to effect of multipath fading available in channel. The difference between the diversity schemes lies in the fact that in time and frequency diversity, there is wastage of bandwidth due to duplication of the information signal to be sent. Thus problem is avoided in spatial diversity scheme, but at the cost of increased antenna complexity. Thus method of transmission or reception, or both, in which the effects of fading are Minimized by the simultaneous use of two or more physically separated antennas, ideally separated by one half or more wavelengths.

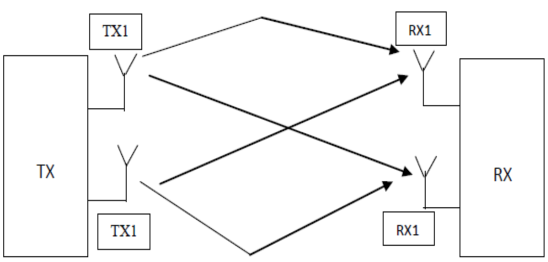


**Figure 1:** Spatial Diversity using MIMO system

## 4. Selection Combining

Selecting the best signal among all the signals received from different braches at the receiving end. Larger the number of available branches, the higher the probability of having a larger signal-to-noise ratio (SNR) at the output. It is seem that among available receive combing techniques at receiver side; SC has worst BER performance [9].

**S (t) = max ($s_1$(t) , $s_2$(t))**

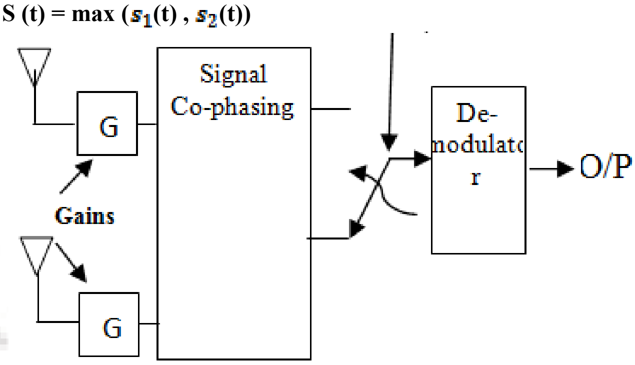


**Figure 2:** Selection combining

## 5. Maximal Ratio Combining

Combining all the signals in a co-phased and weighted manner so as to have the highest achievable SNR at the receiver at all times. The advantage is that more BER improvements can be achieved with this configuration even when branches are completely correlated. The disadvantage of maximal ratio is that it is little complicated and requires accurate estimates of the instantaneous signal level and average noise power to established optimum performance with this combining scheme. Maximal ratio combining will always perform better than either selection diversity or equal gain combining [10].

**S (t) = W. $s_1$(t) + W. $s_2$(t)**

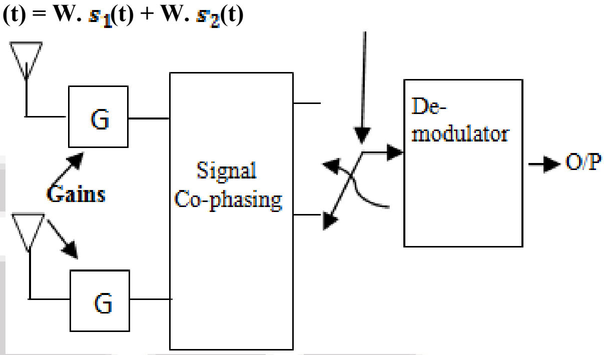


**Figure 3**: Maximal Ration Combing

## 6. Equal Gain Combining

It is same as that of maximal ratio combining (MRC) except that equal gains are taken in this method. Combining all the signals in a co-phased manner with unity weights for all signal levels so as to have the highest achievable SNR at the receiver at all times [11].

**S(t) =$s_1$(t)+$s_2$(t) (having w matrix equal)**

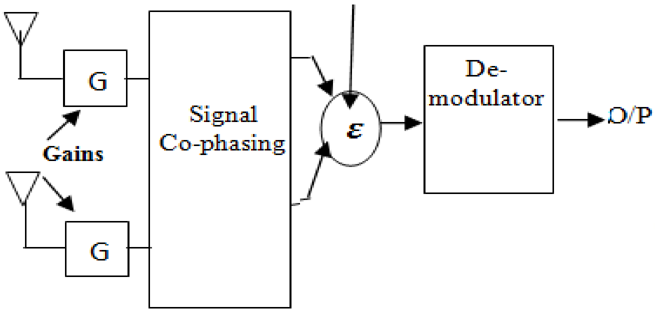


**Figure 4:** Equal gain combining

## 7. LPDC Filter

LDPC codes are linear error correcting block codes which are characterized by its very sparse parity check matrix H. These codes are generally called capacity approaching codes because system capacity using these codes is close to Shannon's capacity limits [12].

So LDPC code is a method of transmitting a message over a noisy transmission channel and is constructed using a sparse bipartite graph. LDPC codes are capacity-approaching codes, which means that practical constructions exist that allow the noise threshold to be set very close to the theoretical maximum (the Shannon limit) for a symmetric memory-less channel. The noise threshold defines an upper bound for the channel noise, up to which the probability of lost information can be made as small as desired. Using iterative belief propagation techniques, LDPC codes can be decoded in time linear to their block length [13].LDPC codes are defined by a sparse parity-check matrix. This sparse matrix is often randomly generated, subject to the sparsity constraints. These codes were first designed by Gallager in 1962.Below is a graph fragment of an example LDPC code using Forney's factor graph notation. In this graph, *n* variable nodes in the top of the graph are connected to (*n*−*k*) constraint nodes in the bottom of the graph. This is a popular way of graphically representing an (*n*, *k*) LDPC code. The bits of a valid message, when placed on the **T's** at the top of the graph, satisfy the graphical constraints. Specifically, all lines connecting to a variable node (box with an '=' sign) have the same value, and all values connecting to a factor node (box with a '+' sign) must sum, modulo two, to zero (in other words, they must sum to an even number). LDPC encoding algorithm can be represented by bipartite graph called Tanner graph [14]. Fig. 2, it consists of two types of nodes, the symbol nodes or variable nodes $d_j$, which represents transmitted symbols or bits and the parity check nodes $hi$, which represents each row of parity check matrix.

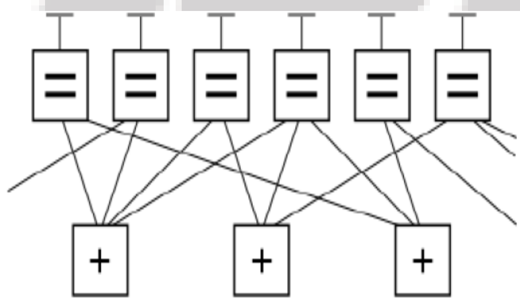

**Figure 5:** Tanner graph showing symbol and check nodes

## 8. New Proposed Technique

The new proposed technique is based on the LDPC filter. The multiple split signals received by receiver are joined together and form the original signal. The bit rate is very high in MIMO-OFDM because of the unique features of OFDM. In this paper, we are proposing the new technique to reduce bit error rate in MIMO-OFDM. The LDPC is used at the receiver side with the multiple signals are merged together to form the complete signal. The simulation results show that bit rate error is reduced when LDPC filter is used with the MIMO-OFDM as compared to convention OFDM. Also compare the different receive combining techniques across receiver end and observe performance in terms of Bit Error Rate.

## 9. Conclusion

In this paper, we conclude that MIMO-OFDM is the efficient approach for fast data transmission. Due to the multipath fading effect of propagation channel bit error rate is very high in MIMO-OFDM. To reduce the bit error rate we use LDPC. Also conclude MRC gives better error rate performance as compare to other two techniques EGC and SC. So simulation results show that more reduction in bit error rate using proposed technique as compared to the previous techniques. In figure 6 comparison is done between Conventional OFDM and OFDM using LDPC method and result shows modified method helps in more reduction in BER. Figure 6 shows the comparison of different receive combining techniques which shows MRC is outperforms well in terms of error rate analysis.

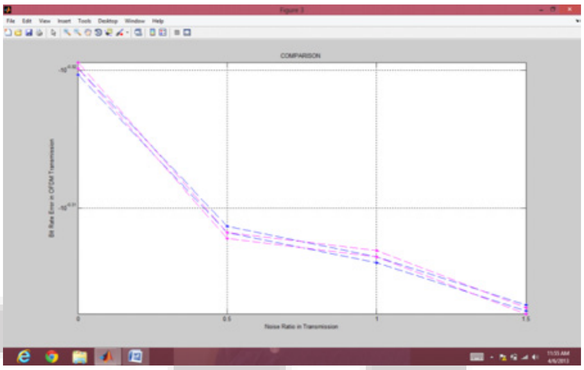

**Figure 6:** BER Comparison b/w conventional OFDM and OFDM with LDPC (modified)

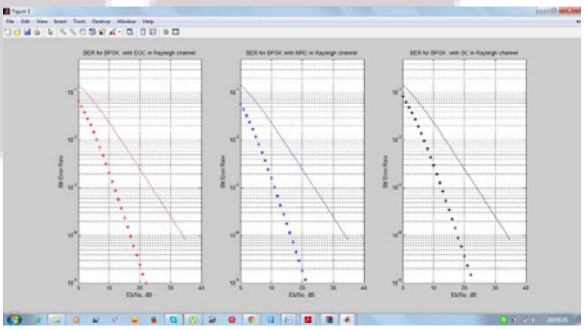

**Figure 7:** Comparison of Different Combining Techniques

## References

[1] Satoshi Gounai and Tomoaki Ohtsuki, " Performance Analysis of LDPC Code with Spatial Diversity," IEEE

international conference on Vehicular Technology, pp 1-5, 2005.

[2] Eric Villier, " Performance Analysis of Optimum Combining with Multiple Interferers in Flat Rayleigh Fading", IEEE Communication Letters, vol. 47, No. 10, pp.1503-1510, 1999.

[3] David J. C. MacKay, " Good Error-Correcting Codes Based on Very Sparse Matrices", IEEE Transactions of information theory, vol. 45, no. 2, pp. 399-431,1999.

[4] D. G. Brennan, "Linear diversity combining techniques," Proc. IRE, vol. 47, pp. 1075-1102, June 1959.

[5] M.-S. Alouini and M. K. Simon, "An MGF-based performance analysis of generalized selection combining over Rayleigh fading channels," IEEE Trans. Commun., vol. 48, pp. 401- 415, Mar. 2000.

[6] Suchita Varade, Kishore Kulat," Performance Analysis of MIMO-OFDM System using Space-time Turbo Codes and Adaptive Beamforming", International Journal of Computer Applications (0975 – 8887) Volume 22– No.3, May 2011.

[7] Debasis S.N Das, Sarmistha Satrusallya, Mihir N. Mohanty," Reduction of PAPR in MIMO-OFDM Broadcasting System", Special Issue of International Journal of Computer Applications (0975 – 8887) International Conference on Computing, Communication and Sensor Network (CCSN) 2012.

[8] Theodore S. Rappport, " Wireless Comm.: Principles and Practice",2nd Edition, Prentice-Hall,India.

[9] ME Thesis, Palak Patel, Gujarat technological university, "Performance analysis of different diversity combining techniques with MIMO channel in wireless", June 2012.

[10] Fangming He, Hong Man and Wei Wang, "Maximal Ratio Diversity Combining Enhanced Security", IEEE Communications Letters, Vol-15, and Issue: 5, pp-509 – 511, May 2011.

[11] Rizvi, Yilmaz, Janssen, Weber and louin, "Performance of Equal Gain Combining with Quantized Phases in Rayleigh Fading Channels", IEEE Transactions on Communications, Vol-59, Issue: 1, pp -13 – 18, January,2011

[12] D. J. C. Mac Kay and R. M. Neal, Near Shannon limit performance of Low Density Parity Check Codes, Electronics Letters, Vol.32, No.18, 1996, pp. 1645–1646.

[13] Y. Awad, L.H. Crockett ,et.al." Ofdm Transceiver for ieee 802.20 Standards".

[14] L. M. Tanner, A recursive approach to low complexity codes, IEEE Transactions on Information Theory, Vol. 27, No.5, 1981, pp. 533 –547, 1981.

## Author Profile

**Naveen Kumar** has received B- Tech Degree in 2012 from Ct Group of Institution, Jalandhar; Punjab. He is currently pursuing M.Tech degree in Lovely Professional University , Punjab , India. His area of interest is in Wireless Communication, OFDM and MIMO system.

**Arvinder Pal Singh Kalsi** has received M -Tech Degree in 2012 from Thapar University, Patiala. He is currently working as Assistant Professor in Lovely Professional University , Punjab , India. His area of interest is in Wireless Communications (SDR). He has been into the research since 2010.