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Review of MIMO-OFDM System Using Simulink Model

Amit Shivhare[1*], Ravi Kumar[2], Manish K. Patidar[3]

[1,2,3]Electronics and Communication Engineering Department, Jaypee University of Engineering and Technology, Guna, M. P. India-473226

*Corresponding Author: amitshivhare756@gmail.com

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***Abstract*—** Present time demands for high-speed 4G broadband wireless network is enabled by the practice of multiple antennas at both the transmitter and receiver ends. The multiple-input multiple-output MIMO transmission creates parallel channels over the same time and frequency i.e. spatial multiplexing to achieve high capacity and link reliability without the need for additional power of spectrum. Thus, MIMO transmission exploits the multipath fading mechanism to increase data rate and system capacity. However, in order for MIMO systems to function, there has to be a means of "slicing" the carrier signal into multiple subcarriers that modulate the low-frequency information data. These parallel low-rate subcarriers can then be transmitted and received via the multiple antenna configurations. Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation technique that creates these parallel sub-channels that are low-rate or narrowband in nature. By inserting cyclic prefix between the sub-channels, orthogonality is maintained and inter-symbol interference is totally eliminated. Hence, a combination of MIMO and OFDM i.e. MIMO-OFDM not only drastically improves channel capacity and data rates, it also combats frequency-selective fading thereby improving link.

***Keywords*—** MIMO, OFDM, Spatial multiplexing and frequency selective fading.

I. INTRODUCTION

The first cellular scheme was applied by NIPPON TELEPHONE AND TELEGRAPH, Tokyo, Japan in the 1980's. Analog modulation systems were predominantly used. The high-speed Mobile Phone Systems became common in the United States in late 80's. 40 MHz bandwidth was assigned within the radio bandwidth of 800 MHz to 900MHz whereas additional 10 MHz bandwidth was added to achieve better performance. The Advanced Mobile Phone Systems was using only speech transmission by Frequency Modulation Technique [1]. After that 1.5G was evolved providing an improvisation to 1G. Later digital modulation scheme (2G) came into the market which used digital transmission of speed and data. Another significant thing was it is efficient in spectrum discrimination and used multiple access techniques such as time division multiple access (TDMA), frequency division multiple access (FDMA) etc. Then the 3G (third generation) mobile cellular system came into existence and it permitted high speed data broadcasting and internet access. Voice activated calls also supported by 3G. Now the 4G system has become a hot issue. It confirms us data speed more than 100Mbps i.e. almost no unused bandwidth as well as multi mega bit internet access. But this type of network designing such a real challenge involved in 4G. The SISO (single input single output) can never achieve the barrier of 100Mbps.

II. MULTIPLE INPUT MULTIPLE OUTPUT MODEL

Systems using multiple transmit and multiple receive antennas are generally known as multiple input multiple output (MIMO) systems [2]. Both the range and the capacity of a wireless communication system greatly improve this technology [3]. When increasing the number of transmitting and receiving antennas, the capacity of MIMO system also increases. As an increase in capacity means ability of faster communication to achieve high data speed. so, the MIMO system is being used in current technology to develop the high-speed data rate network [4]. Usually, the antenna array is being used in base station, as there is cheaper to install multiple antennas at base stations only. Various antenna configurations such as 2x2, 3x2, 4x4 etc. with several antennas at both ends can be classified as MIMO systems. Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation technique which is mainly used for transmission over a dispersive channel. In OFDM the different type of carriers used which are orthogonal to each other and also independent of each other [5]. OFDM is a wideband modulation scheme that is used to multi carrier transmission to develop high speed data rate at lower band width. This is occurred because we communicate many narrowband digital signals in parallel. The progress of OFDM systems can be separated into three parts [6]. They are Frequency Division Multiplexing, Multicarrier Communication and Orthogonal Frequency Division Multiplexing. [7] The combinations of OFDM and MIMO have widely been used nowadays for improving the data rates. Various other techniques and improvements at system model level are being implemented in MIMO-OFDM technique to receive more improvements.

III. LITERATURE REVIEW

The execution of wireless communication technique is mainly controlled by the wireless channel environment. In wireless channel the transmission medium is always considered as air. The communicated signal may get echoed from many things like hills, trees, etc. previously being received at the receiver. This can provide multiple transmission routes up to the receiver. The comparative phases of the multiple replicated signal cause destructive interference at the receiver. This characteristic of phase difference in a wireless channel is a phenomenon called 'fading,' where the variation of the signal amplitude over time and frequency is observed [8]. Two types of fading generally occurs, first one is large-scale fading and second is small-scale fading. When the mobile moves through a huge distance, large scaling fading occur. On the other hand, small-scale fading refers to quick variation of signal levels due to the destructive interference of multiple signal paths (multi-paths) when the mobile station travels short distances. In any wireless transmission, the channel spectral reply is not flat. The fading occurs due to reflections of received signals at receiver end after observing some cancellation of certain frequencies. Reflections from neighbouring object (e.g. trees, ground, buildings, etc.) leads to multipath signal of similar signal power as the direct signal. These outcomes the nulls in received signal power due to the interference. For small bandwidth transmission, if the null of the frequency response occurs in the spread frequency then the entire signal might be lost. There are two ways to overcome this problem, first one is transmitting the wide bandwidth signal or spread spectrum as in CDMA, so the dip of the spectrum is observed which concludes the small loss of resulting signal power [9]. Second method is to spill the transmitting signal bandwidth into many sub bandwidth carriers to reduce signal power loss; this is done by OFDM technique. This result in the occurrence of very less carrier loss and the entire transmitted signal recover by the receiver end.

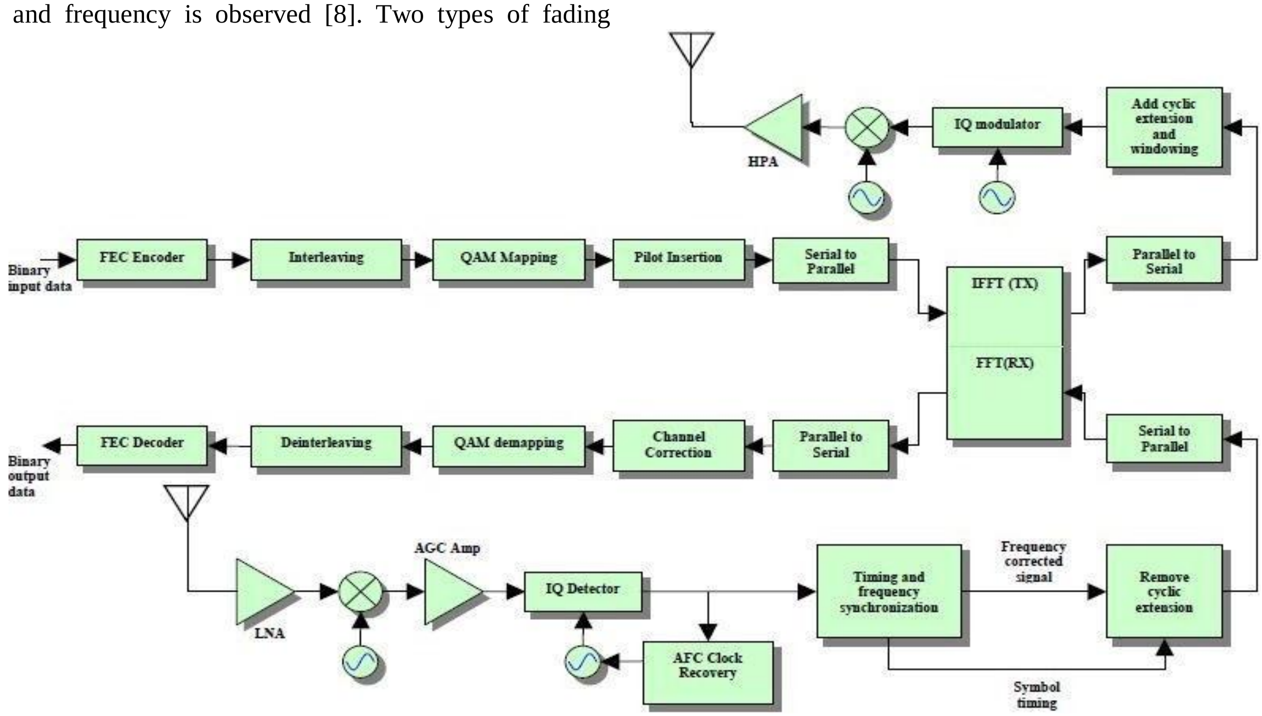


Figure 1. Block Diagram of OFDM transceiver

IV. OFDM FUNDAMENTALS

Orthogonal Frequency Division Multiplexing (OFDM) is a technique in which the carriers are multiplexed together for the modulation purpose, in which the bandwidth is distributed into many sub-carriers; every carrier is modulated by a low rate data stream. In terms of multiple access technique, OFDM is like FDMA, in which several user accesses are reached by subdividing the existing bandwidth into many channels that are then allocated to users [10].

However, OFDM uses the spectrum more efficiently by providing channel spacing much closer together. The figure 1 shows the OFDM transceiver and difference between the conventional multicarrier technique and overlapping multicarrier modulation technique. In OFDM technique, approximately 50% of bandwidth is saved.

V. OFDM GENERAL STRUCTURE AND IMPLEMENTATION

Key Distinction of OFDM is its orthogonality. When the integral of the product of two periodic signals is equal to zero over one period then two periodic signals are orthogonal. The OFDM carriers of sinusoidal signal that meet this requirement are because of the reason that every signal is multiple of carrier frequency.

Transmitter: In the typical OFDM system the serial binary data is encoded into parallel form which reduces bit rate per carrier. This parallel data is mapped by using any suitable modulation technique. The IFFT block is provided for maintaining orthogonality among the sub carriers which is decoded properly with an FFT block on the receiver side. The IFFT block receives modulated data and transforms this data into time domain signal maintaining the orthogonality of the OFDM signal.

Receiver: This data is received at the receiver and the CP or guard interval is removed from the OFDM symbol. Then the data is converted from S/P. This parallel data is transformed by the FFT block and the time domain signal gets converted into frequency domain signal. The signal is further demodulated and decoded. Thus, the received symbol is equalized and detected to retrieve the original transmitted symbol. The use of FFT avoids the complexity in the circuit. It reduces the number of modulators and filters to be used at the transmitter as well as complementary filters and demodulators at the receiver.

MIMO System Model: The model of MIMO – OFDM system is shown in figure 2. The MIMO system consists of two transmit and two receive antenna [11]. The OFDM signal in transmitter side can be obtained by applying the inverse Fast Fourier transform (IFFT) and Fast Fourier transform (FFT) can be used for detecting received signal [12]. Pilot carriers are being used for the channel estimation in this model. Further, cyclic prefix is introduced in front of the OFDM symbol of modulation block [13]. The cyclic prefix time length should be superior to the maximum delay spread of the channel [14].

VI. MATHEMATICAL MODELLING

In wireless communications network many factors are introduced like diffraction, reflection, scattering and shadowing of the transmitted signals due to neighbouring objects causes multipath propagation and as a significance, the transmitted signals reached at the receiver with different phase angles, amplitude and interval of time. The channel response consisting the transmit antenna to the jth receive antenna can be given as

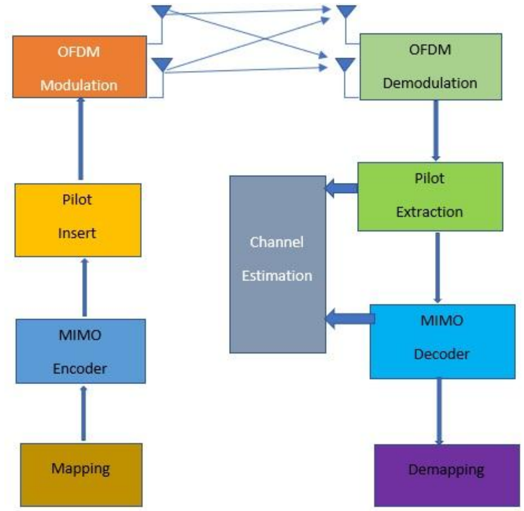


Figure 2. Block Diagram of MIMO -OFDM System Model

$$h_{i,j}(t) = \sum_{l=0}^{L-1} a_{i,j}(i)\delta(t-\tau_1) \quad (1)$$

where, $a_{i,j}(i)$ shows the multi-path gain coefficient, l represents the number of resolvable paths, and τ_l denoted the path delay time l_{th} of multi-path component. The frequency response of the channel is given by

$$h_{i,j}^{k}(f) = \sum_{l=0}^{L-1} a_{i,j}^{k}(l)e^{-j2\pi f\tau l} \quad (2)$$

Alamouti developed special type of code which is used to transmit multiple streams known as space-time block code (STBC). Two successive symbols x_1 and x_2 are encoded with the STBC following matrix as follows in figure 3,

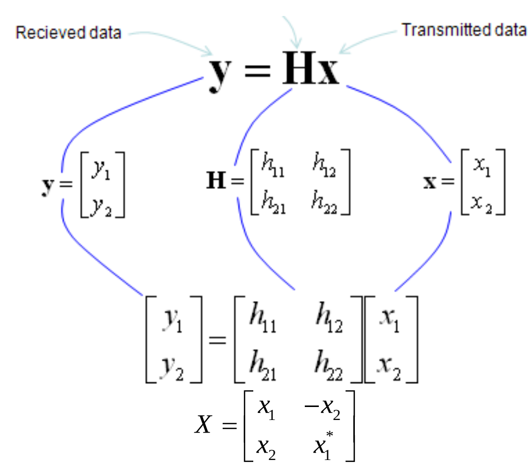


Figure 3. Channel information matrix

VII. CONCLUSION

The combination MIMO-OFDM is very useful to use multiple antennas at both transmitter and receiver to achieve larger bandwidth. MIMO – OFDM supports many wireless networks like 802.11, 802.16 and LTE etc. In future, MIMO technology will be using more antenna and achieve good signal to noise ratio (SNR). The space time blocking code (STBC) has a good technology to implement multiple antenna technology and in future, the work of STBC produce a great result in MIMO system. The combination of MIMO and OFDM may be used to increase the spectral efficiency to achieve 1 Gbit/sec with high link reliability.

REFERENCES

[1] H. Bölcskei and E. Zurich, "MIMO-OFDM Wireless Systems: Basic, Perspectives and Challenges", IEEE Transaction on Wireless Communication, vol. 13, August, pp. 31-37, 2006.

[2] T.S Rappaport., "Wireless Communications Principles and Practice", Pearson publication, India, pp 295-300, 2010.

[3] W. Li, H. Zhao, C. Zhang, L. Zhao, and R. Wang, "Generalized selecting sub-carrier modulation scheme in OFDM system," in IEEE Int. Conference Communication Workshops, pp. 907–911, 2014

[4] Aditya K. Jagannathan, "Wireless Communication", McGraw-Hill Publication, India,, pp. 198-221.

[5] Ravi Kumar and Rajiv Saxena, "Performance Analysis of MIMO STBC Systems with Higher Coding Rate using Adaptive Semi-blind Channel Estimation Scheme", The Scientific World Journal, Vol.no. 1, pp. 1-17, January 2014.

[6] L. Hanzo, J. (Jos) Akhtman, L. (Li) Wang, and M. Jiang, "*MIMO-OFDM for LTE, Wi-Fi, and WiMAX": coherent versus non-coherent and cooperative turbo-transceivers*., wiley online publishers,pp 195-234 Aug.2010.

[7] M. I. Kadir, H. Zhang, S. Chen, and L. Hanzo, "Entropy Coding Aided Adaptive Subcarrier-Index Modulated OFDM," *IEEE Access*, vol. 6, pp. 7739–7752, 2018.

[8] Mahdi Nassiri, Gholamreza Baghersalimi, "Comparative performance assessment between FFT-based and FRFT-based MIMO-OFDM systems in underwater acoustic communications", *Communications IET*, vol. 12, no. 6, pp. 719-726, 2018.

[9] W. Zhang, X.-G. Xia, and K. Ben Letaief, "Space-time/frequency coding for MIMO-OFDM in next generation broadband wireless systems," IEEE Wireless Communication, vol. 14, no. 3, pp. 32–43, Jun. 2007.

[10] Y. Xiao, S. Wang, L. Dan, X. Lei, P. Yang, and W. Xiang, "OFDM with interleaved subcarrier-index modulation," IEEE Communication Letters, vol. 18, no. 8, pp. 1447–1450, Aug. 2014.

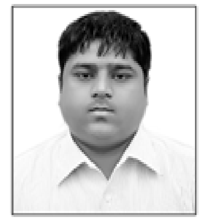
[11] K. Nagarajan, V. V. Kumar, and S. Sophia, "Analysis of OFDM systems for high bandwidth application," in *2017 International Conference on Nextgen Electronic Technologies: Silicon to Software (ICNETS2)*, pp. 168–171, 2017.

[12] H. Bolcskei, D. Gesbert, and A. J. Paulraj, 'On the capacity of OFDM-based spatial multiplexing systems' IEEE Transactions on Communications, vol. 50, no.2, pp. 225– 234, 2002.

[13] S.M. Nimmagadda, "*Full Code Rate Complex Non-Orthogonal STBCS for Eleven Transmit Antennas*", International Journal of Scientific Research in Computer Science and Engineering, Vol.5, Issue.2, pp.21-25, 2017.

[14] R. Deshpande, DJ. Pete, "*An Efficient PAPR Reduction Technique for OFDM*", International Journal of Scientific Research in Network Security and Communication, Vol.5, Issue.1, pp.29-33, 2017.

Authors Profile



Amit Shivhare pursued Bachelor of Enginnering from Samatr Askok Technological Institute Vidisha,india in 2010 and Master of Engineering from Rajiv Gandhi Proudyogiki Vishwavidyalaya (RGPV) Bhopal India in year 2015. He is currently pursuing Ph.D, Department of Electronic and Communication, Jaypee University of Engineering and Technology, Guna.His Aria of Reseaech are communication and Antenna.

Ravi Kumar is Ph.D. from Department of Electronics and Communication Engineering, Jaypee University of Engineering & Technology, Guna and working at the same University as Assistant Professor (SG) His specialization is in MIMO Communication Systems and Smart Antennas. He has Eight months Research Experience as Project Associate in Radio and Science Division (RASD) department at National Physical Laboratory, New Delhi where his topic was "Post Earthquake Rescue System and Real-time Data Acquisition" and one of the module was completed by him on Real-time Data Acquisition for the above given DST sponsored project. He has published various research papers in journal of repute and working as editorial team member of various journals. He is also active reviewer at International level for various highly indexed journals. He is Senior member of IEEE, UACEEE and Fellow member of IETE.

Manish K. Patidar received B.E. from R.G.P.V., Bhopal in 2002 and M.E. from D.A.V.V. Indore in 2005. He completed Ph.D. in "Efficient PAPR Regulation in OFDM system using Soft Computing Techniques" from JUET Guna in 2015. He has Twelve years of teaching experience and guided several project at undergraduate and postgraduate level. He has published several research papers in referred including SCI indexed journals.