http://www.jctjournals.com ISSN(ONLINE):2278 – 3814

Volume-11, Issue-07, July 2022
JOURNAL OF COMPUTING TECHNOLOGIES (JCT)
International Journal
Page Number: 01-09

HUGE OAM-MIMO TRANSMISSION TECHNIQUE FOR 5G COMMUNICATION APPLICATIONS

Dheeraj Kumar Rajpal[1], Prof Shivraj Singh[2],
PG Scholar(M.Tech)[1], [2]Assistant Professor,
Department of Electronics And Communication[12],
[1,2]Technocrats Institute of Technology, Bhopal(M.P), India
dheeraj907@gmail.com, 86.shivraj@gmail.com

***Abstract*— Recently, wireless communication using OAM (Orbital Angular Momentum) has drawn much attention as an emerging candidate for beyond 5G (fifth generation) technology due to its potential as a means to enable high-speed wireless transmission. OAM is a physical property of electro-magnetic waves that are characterized by a helical phase front in the propagation direction. Since the characteristic can be used to create multiple independent channels, wireless OAM multiplexing can effectively increase the transmission rate in a point-to-point link such as wireless backhaul and/or fronthaul. This dissertation presents implementation and performance analysis of orbital angular momentum with OFDM wireless communication system. MATLAB 2018 software used to implement and simulate the proposed methodology. Simulation results show that the proposed OAM-OFDM approach simulation gives significant achievement than existing algorithm. Parameter calculation shows that the improved UCA radius with saving of power consumption. This research is focus on the development of OAM with OFDM for MIMO based system. The optimized value of signal to noise ratio is 40dB and BER is 10-4.**

Keywords - Orbital Angular Momentum, MATLAB 2018, Fifth Generation, Bit Error Rate (BER), and Multi input multi output (MIMO).

I. Introduction

Nowadays, with the rapid development of wireless communication technologies for information exchange, the number of mobile terminals has increased dramatically, and the mobile Internet has shown an explosive development trend. In order to meet the growing demand for mobile data services, there is an urgent need for a new generation of wireless communication technologies with higher speed, greater bandwidth, and higher efficiency. Electromagnetic vortex beam orbital angular momentum (OAM) becomes the fifth new dimension that is expected to improve spectrum efficiency beyond the four dimensions of amplitude, phase, frequency, and polarization that electromagnetic waves have been utilized. It is common knowledge that electromagnetic waves can carry the linear momentum as well as angular momentum, which is divided into spin angular momentum (SAM) and OAM [1].

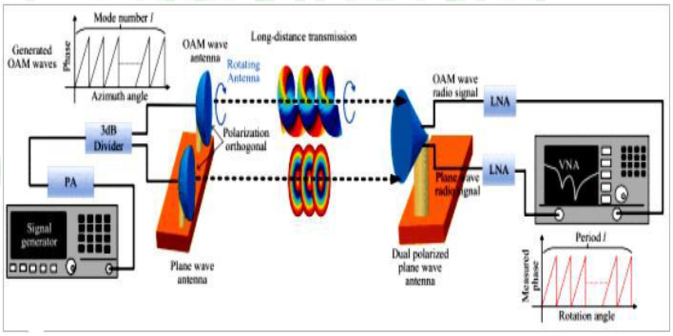

Figure 1.1: Orbital Angular Momentum

Recently, wireless communication using orbital angular momentum (OAM) has drawn much attention as an emerging candidate for beyond 5G (fifth generation) technology due to its potential as a means to enable high-speed wireless transmission. OAM is a physical property of electro-magnetic waves that are characterized by a helical phase front in the propagation direction. Since the characteristic can be used to create multiple independent channels, wireless OAM multiplexing can effectively increase the transmission rate in a point-to-point link such as wireless backhaul and/or front haul [1,2]. Since OAM multiplexing technology is relatively new, it is important to validate the feasibility from various perspectives.

1.2 OAM MODE :- The second part of our work was validating the feasibility from beam generation and propagation perspectives. In particular, we expanded our study to the usage of a dielectric lens to examine the feasibility of long distance transmission using OAM [5]. Ideally, all OAM modes are orthogonal to each other due to the unique nature of their phase fronts. However, with these modes, it is difficult to transmit over long distances because their energy rapidly diverges as the beam propagates. To achieve long-distance transmission, we developed and proposed a beam divergence reduction method using the focusing effect of a dielectric lens. We conducted a wave propagation experiment on 28 GHz bands to demonstrate the effectiveness of using such a lens. In the experiment, we were able to generate OAM modes 0, ±1, and ±2. In addition, we showed the beam divergence reduction effect by making a comparison between conventional OAM beam generation methods and using a dielectric lens with a UCA.

II LITERATURE SURVEY

The theoretical and experimental works from different types of multiplexing and OAM related multiplexing discussed. This section briefly describes various improvements in performance in terms of signal interference noise ratio and cell radios. The following reviews provide a comprehensive survey about the developments in the state of art OAM-OFDM technology around the world.

A. Yamamoto et al.,[1] Orbital angular momentum (OAM) is an actual amount of an electromagnetic wave which is free of polarization, and the electromagnetic wave having the OAM turns into a helical wave. A method of the OAM can be characterized by the quantity of turns of helix per frequency distance, and the various modes are symmetrical together. As of late, with development of the millimeter wave innovation and requests for additional fast enormous limit transmission, a new spatial multiplexing transmission plot utilizing the symmetry of OAM has stood out. In this work, the effect of the ground reflected wave were assessed by contrasting the qualities of OAM mode multiplexing and eigenbeam-space division multiplexing. Thus, it is tracked down that the between mode obstruction because of the ground reflected wave isn't really huge and can be diminished with a limited quantity of debasement.

K. Mofoka et al.,[2] Orbital angular momentum (OAM) with list tweak (IM) (OAM-IM) is an as of late proposed view remote correspondences method that has been drawing in ongoing consideration. OAM-IM uses the files of initiated OAM mode blends to pass on extra data per transmission stretch. Full-duplex transferring (FDR) might be utilized to further develop correspondence range, unearthly proficiency or mistake execution in remote correspondence frameworks. In light of a legitimate concern for further developing the mistake execution of OAM-IM while permitting broadened correspondence range, in this work, we present three variation FDR plans for single-dynamic mode orbital rakish energy record balance (FDR-SA-OAM-IM). A transmission component for the proposed plans is planned for the connection between the source and
hand-off hubs (Connection 1) and between the transfer and objective hubs (Connection 2). Plot 1 utilizes OAM mode division multiplexing (OAM-MDM) for Connection 1 and Connection 2. Plot 2 utilizes single-dynamic OAM-IM (SA-OAM-IM) for both Connection 1 and Connection 2. Conspire 3 utilizes SA-OAM-IM for Connection 1 and OAM-MDM for Connection 2. The normal piece mistake likelihood of the proposed plans is attested by the Monte Carlo reenactments, and we uncover that the FDR component shows a for the most part improved blunder execution.

Almaiman et al.,[3] We exhibit utilizing OAM modes to convey header data of a sign for directing. We show encoding the header on a solitary OAM mode or a codeword of various OAM modes. We notice 0.4-0.8 dB punishment for 10 Gb/s OOK signal exchanged at 10Mb/s rate.

H. Suganuma et al.,[4] This work proposes a between mode obstruction concealment strategy that utilizes just even-numbered modes for uniform round cluster (UCA)-based orbital precise force (OAM) multiplexing. Considering that obstruction from nearby OAM modes becomes serious when the bar pivot is skewed, the proposed strategy utilizes just the even-numbered modes while leaving the odd-numbered modes unused, which actually forestalls the between mode impedance. Additionally, we check the viability of the proposed technique by applying it to different info and numerous result (MIMO) with zero-constraining (ZF) alone or ZF with progressive impedance scratch-off on the grounds that extreme between mode obstruction is brought about by communicating various streams from various UCAs in every mode. The adequacy of the proposed strategy contrasted and the customary technique, which utilizes all OAM modes, is exhibited as far as the framework limit through programmatic experiences.

C. Li et al.,[5] Further requests on information transmission bring new difficulties for the capacity of remote organization because of the quick improvements of remote correspondence innovation. Since various orbital rakish energy (OAM) modes are symmetrical to one another and different transmissions can be sent at a similar recurrence, OAM multiplexing innovation is a compelling strategy to expand the limit of remote channel, which has drawn in much consideration as of late. The examinations on age of OAM waves is huge for the application and advance of OAM multiplexing technology.In this work, another three-layered setup of cluster radio wire is introduced to produce vortex electromagnetic waves conveying orbital precise energy. The proposed round exhibit recieving wire (SAA), which is made up with M layers uniform roundabout cluster radio wire (UCA) and every UCA contains N recieving wire components, is a spatial development in view of UCA and all recieving wire components are conveyed on a circular surface of a similar span. Different OAM modes are acquired by changing the stage conveyance of recieving wire components when the amplitudes are consistently disseminated. To exhibit the practicality of the cluster plan, the hypothetical examination of the far-field and vector potential articulations are extravagantly concluded. In addition, two circular cluster radio wires with various constructions are reproduced and the reproduction results exhibit that different OAM modes can be created, which further confirm the hypothetical conversation. This new exhibit design performs better in radiation directivity contrasted and the traditional UCA, so the shaft is more thought and gainful to significant distance transmission and gathering for the vortex electromagnetic waves.

III. ORBITAL ANGULAR MOMENTUM

3.1NEED OF OAM

As wireless communications migrate from the fourth-generation (4G) to the fifth-generation (5G) and beyond, it is highly demanded to meet the requirements of explosive data traffic. For example, the aggregate data rate is expected to be increased by roughly 1000 times for 5G as compared with 4G [1]. It is expected using 5G and 5G-beyond New Radio (NR) for spectrum efficiency enhancement with advanced techniques, such as massive multiple-input multiple-output (MIMO), co-frequency co-time full-duplex, and millimeter-wave (mmWave) [1], [2]. For 5G NR, the promise of significant spectrum efficiency enhancement, vast spatial diversity, and simple transmit/receive structure has elevated massive MIMO to a central position in 5G wireless communications networks, with a foreseen role of coexisting with mmWave [3]. Co-frequency co-time full-duplex, which potentially double the spectrum efficiency, is expected to be integrated into future 5G-beyond wireless communications networks [4]. However, during the past few decades, multiple orthogonal resources, such as frequency, time, and space, were extensively explored.

Nowadays, it becomes more and more difficult to increase capacity or support more users with the traditional access techniques such as time-division-multiple-access and frequency-division-multiple-access. In fact, until now wireless communication is being built on the plane-electromagnetic (PE) wave. However, the electromagnetic (EM) wave possesses not only linear momentum, but also angular momentum, which contains the spin angular momentum (SAM) and orbital angular momentum (OAM). OAM, as a kind of wave front with helical phase, has attracted much research attention [5]. OAM has a great number of topological charges, i.e., OAM-modes. Beams with different OAM-modes are orthogonal to each other and they can be multiplexed/demultiplexed together, thus increasing the capacity without relying on the traditional resources such as time and frequency.

3.2 The OAM Based Wireless Communications :-

Different from frequency/time/code-domain based orthogonal division, OAM offers a new mode domain to support the orthogonal access of multiple users. With OAM, we can re-design the wireless communications because many aspects in wireless communications can be improved with the new orthogonal dimension.

High spectrum efficiency — Different OAM-modes are orthogonal with each other. Thus, in ideal case there is no interference among different OAM-modes. With the orthogonality, the parallel transmission can be performed among multiple OAM-modes. The orthogonality among different OAM-modes can be used to increase the spectrum efficiency in wireless communications without consuming more traditional frequency/time/code/power domain resources. Also, mode-domain resources can be jointly used with frequency/time/code domain resources to significantly increase the spectrum efficiency in wireless communications.

More users access — OAM provides a novel multiple access method, i.e., mode division multiple access (MDMA), without consuming more frequency and time resources. With MDMA, different users can employ different OAM-modes to orthogonally access the wireless networks. Instead of non-orthogonal multiple access, which uses power domain to distinguish multiple users, it is expected to get back to orthogonal multiple access using mode-domain resource in future wireless communications.

High reliability for anti-jamming — Faced with the more and more crowded spectrum pressure, there exist limitations using the conventional frequency hopping techniques for anti-jamming. However, OAM-mode hopping technique has the potential for anti-jamming in future wireless communication. OAM can not only be used within the narrow band, but also jointly used with frequency-hopping in wide band to improve the ability of anti-jamming for wireless communications. Although OAM has the potential to increase the spectrum efficiency, support more users, and improve the reliability of anti-jamming, there are still some important research challenges remaining unsettled. The issues can be classified into three categories: radio vortex signal generation, transmission, and reception.

IV. PROPOSED METHODOLOGY

The main contribution of the proposed research work is as followings-

To design an OFDM-OAM MIMO based model.

To apply Fast Fourier transformation (FFT) operations.

To achieves high sum-rate and spectrum efficiency (SE).

To reduce the complexity of algorithm.

Improve the security due to the modulated signal.

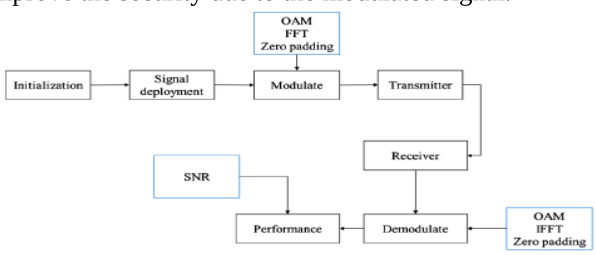

Figure 4.1: Flow Chart

V. METHODOLOGY

Orbital angular momentum (OAM) has attracted considerable attention as a novel solution for wireless communications because its orthogonal modes significantly increase the channel capacity without an additional frequency band. The joint multiplexing between OAM technologies and other modulation techniques has not been thoroughly investigated. In this work, we first proposed the orthogonal frequency-division multiplexing-orbital angular momentum (OFDM-OAM) multiple-input-multiple-output (MIMO) system. The proposed OFDM-OAM MIMO based on the discrete Fourier transformation (DFT) operations achieves a very high sum-rate and spectrum efficiency (SE). However, the expensive hardware and software overheads for transmitting and receiving OAM waves lead to an unexpected cost for the OFDM-OAM MIMO scheme. A time-switched OFDM-OAM (TOO) MIMO is then proposed to reduce the computational complexity, and the procedure of OAM generations and recoveries has also explicitly been derived.

V. SIMULATION AND RESULT DISCUSSION

The implementation of the proposed algorithm is done over MATLAB 9.4.0.813654 (R2018a). The signal processing toolbox helps us to use the functions available in MATLAB Library for various methods like Windows, shifting, scaling etc.

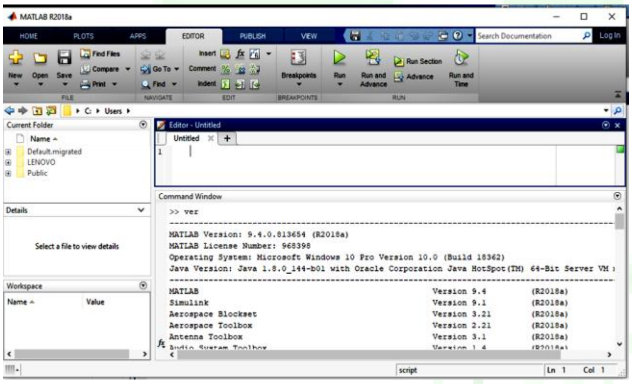

Figure 5.1: Snap shot of MATLAB

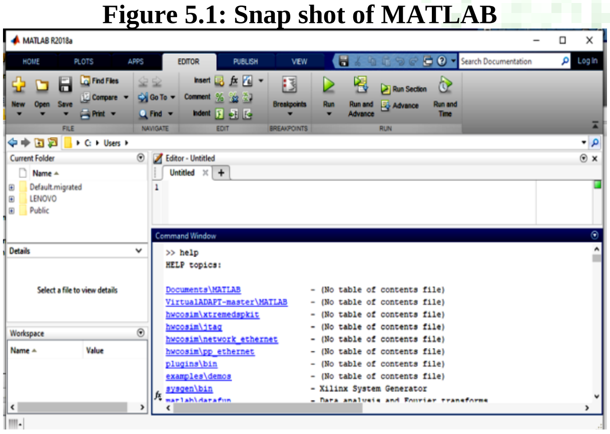

Figure 5.2: Snap shot of MATLAB help

5.1 RESULT AND DISCUSSION The proposed OAM based communication is performed in MATLAB software. The results description is following-

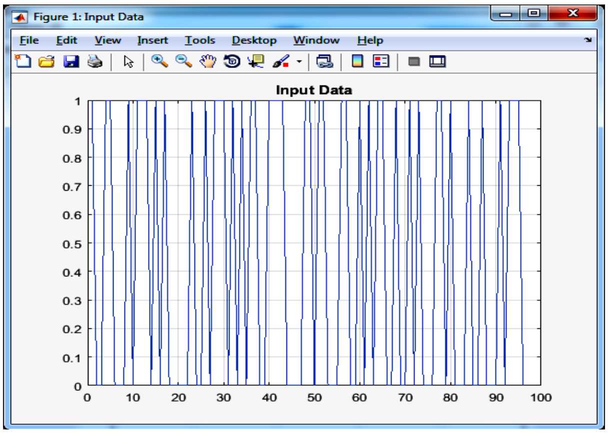

Figure 5.3: Input data

Figure 5.3 is showing the random number signal generation. The maximum amplitude is 1 and time axis shows the signal variation till the 100 sec

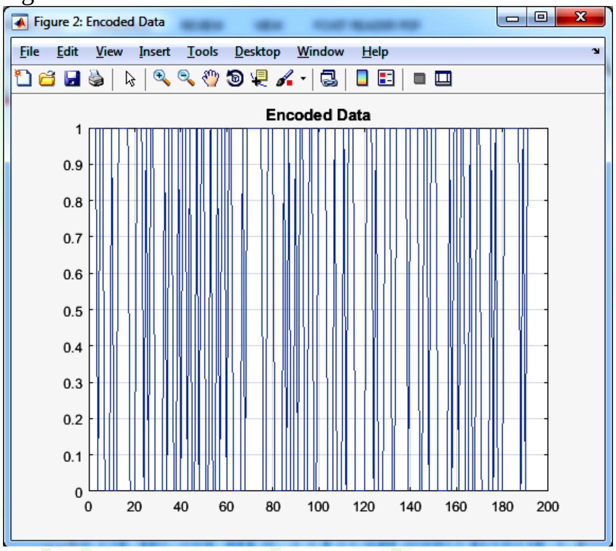

Figure 5.4: Encoded data

Figure 5.4 is showing the encoding of the data sothat it can secure and contain the basic information of the various signal levels.

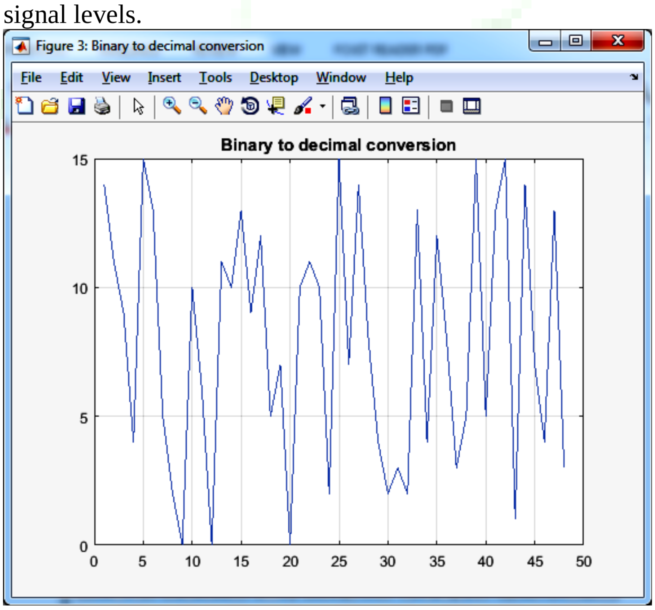

Figure 5.5: Binary to decimal conversion of data

Figure 5.5 is presenting the signal conversion. The signal is assigned in the form of the binary after the encoding process, here needs to convert in to the decimal form so that it can modulate and communicate through wireless channel.

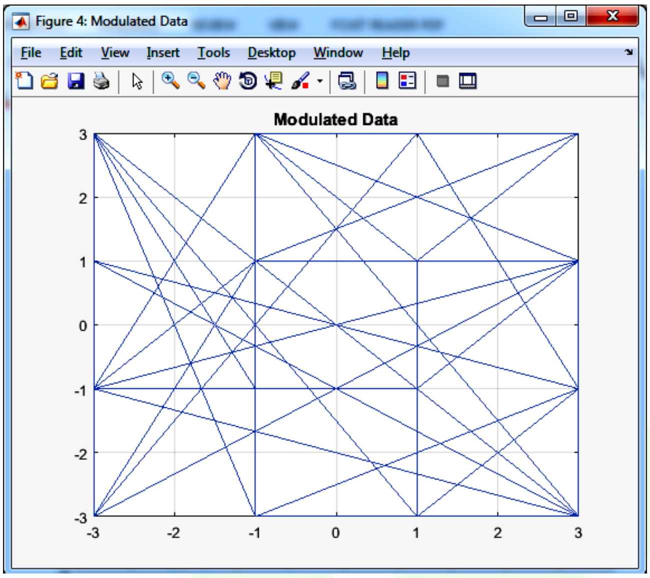

Figure 5.6: Modulated data

Figure 5.6 is showing the modulated data. Here modulation is done using the QAM technique. Quadrature amplitude modulation is one of the good modulation techniques.

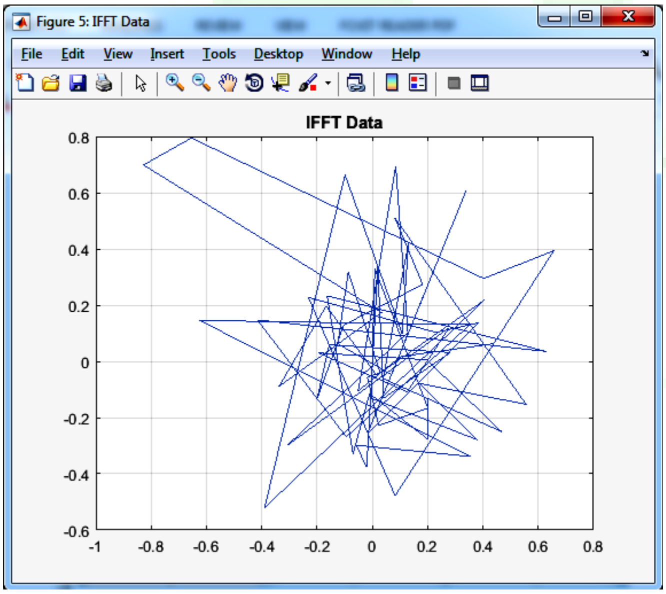

Figure 5.7: IFFT Data

Figure 5.7 shows the IFFT data. Inverse Fast Fourier transform (IDFT) is an algorithm to undo the process of DFT.

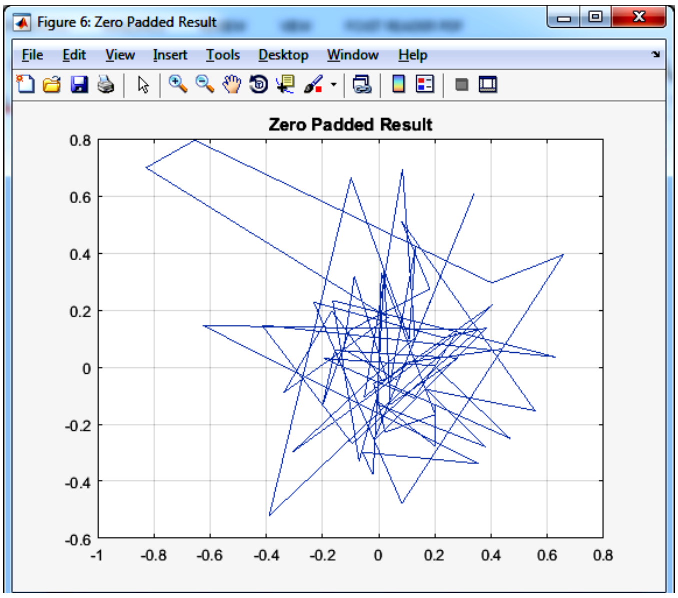

Figure 5.8: Zero padded

Figure 5.8 is showing the zero padding of the signal. It simply refers to adding zeros to end of a time-domain signal to increase its length.

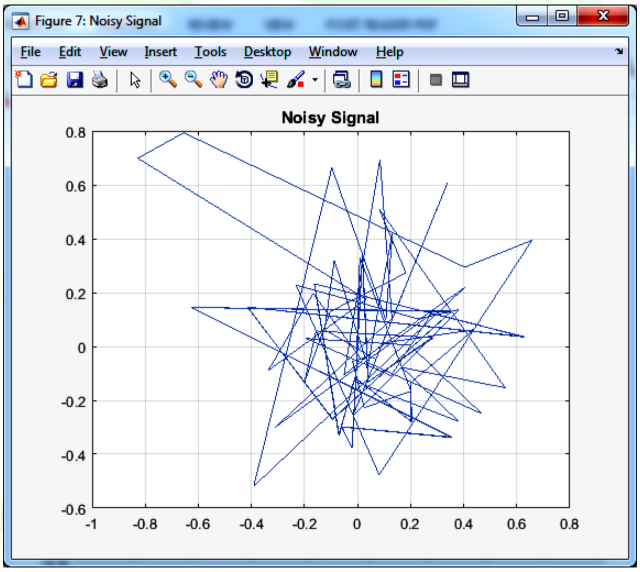

Figure 5.9: Noisy Signal

Figure 5.9 is showing the noisy signal. Here some of the basic level noise include in the present signals.

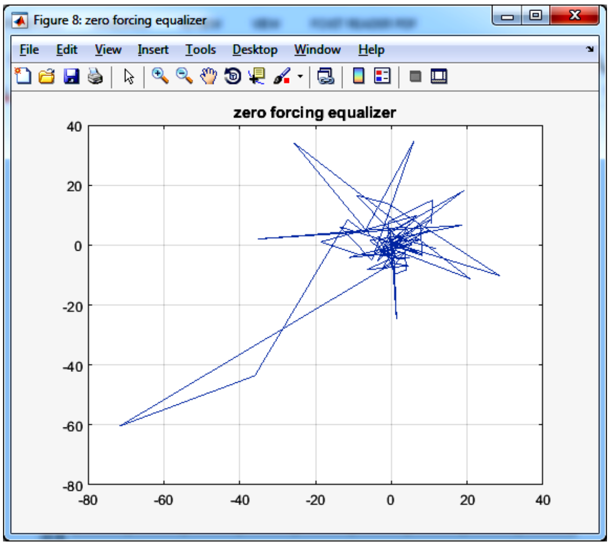

Figure 5.10: Zero forcing equalizer

Figure 5.10 is showing the zero forcing equalizer, which task is a form of linear equalization algorithm used in communication systems which applies the inverse of the frequency response of the channel.

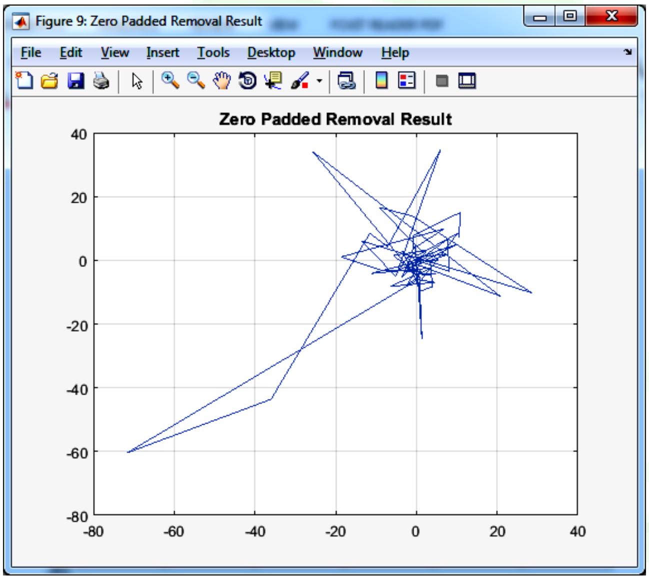

Figure 5.11: Zero padded removal

Figure 5.11 provides the zero padded removal in this step. Zero padding allows one to use a longer FFT, which will produce a longer FFT result vector. After removal of zero padding, extra zeros will be removed.

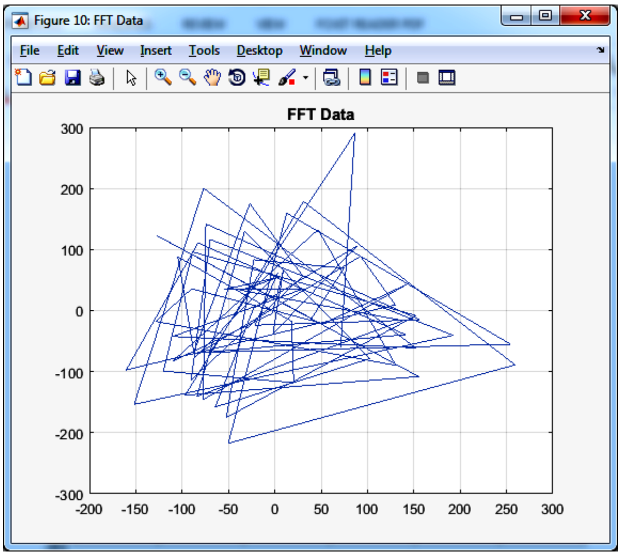

Figure 5.12: FFT data

Figure 5.12 is showing the FFT data. It is an algorithm that computes the discrete Fourier transform (DFT) of a sequence, or its inverse (IDFT).

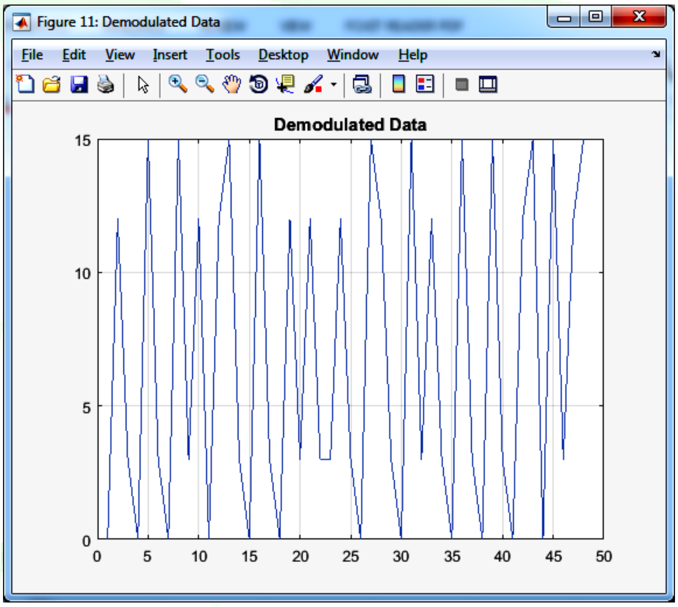

Figure 5.13: Demodulated data

Figure 5.13 is showing the demodulated data. Demodulation is extracting the original information-bearing signal from a carrier wave.

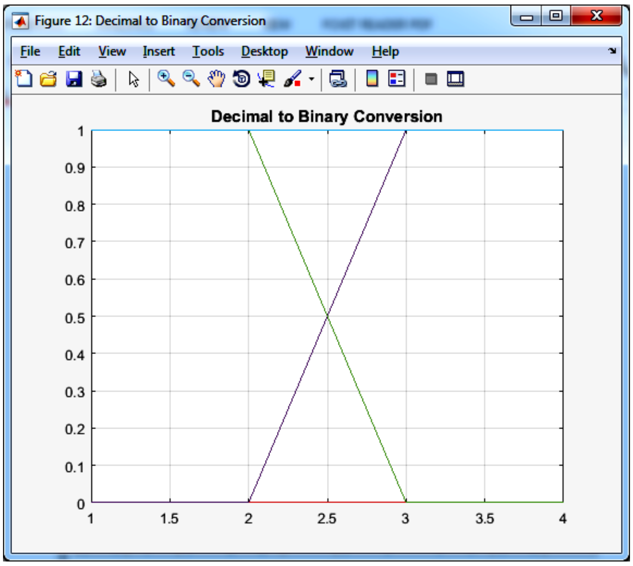

Figure 5.14: Decimal to binary conversion

Figure 5.14 is showing the signal results at the receiver side. The decimal to binary conversion is done at this stage.

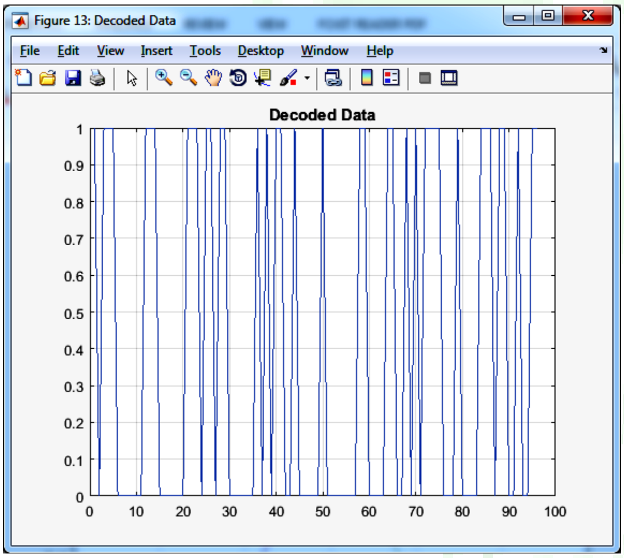

Figure 5.15: Decoded data

Figure 5.15 is showing the decoded data of the signal. Decoding is the process of converting an encoded format back into the original sequence of characters.

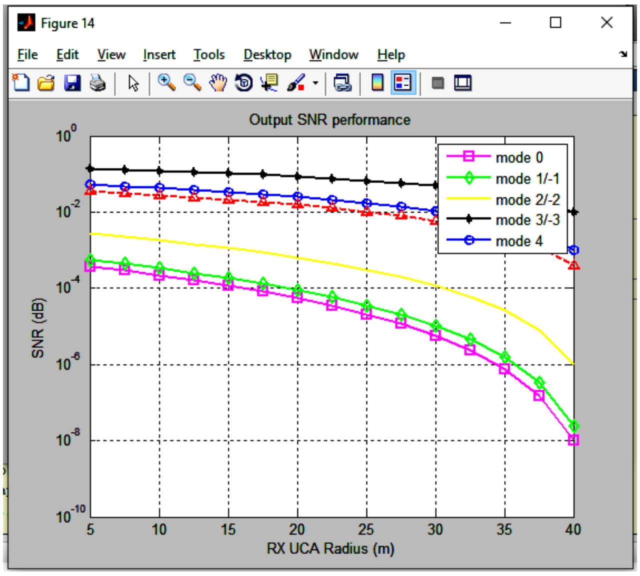

Figure 5.16: SNR performance

Figure 5.16 is showing the output performance in the term of signal to noise ratio and receiver uniform circular array. There are 5 different mode of operation of OAM i.e. mode 0, mode 1/-1, mode 2/-2, mode 3/-3 and mode 4. The UCA radius is 30m.

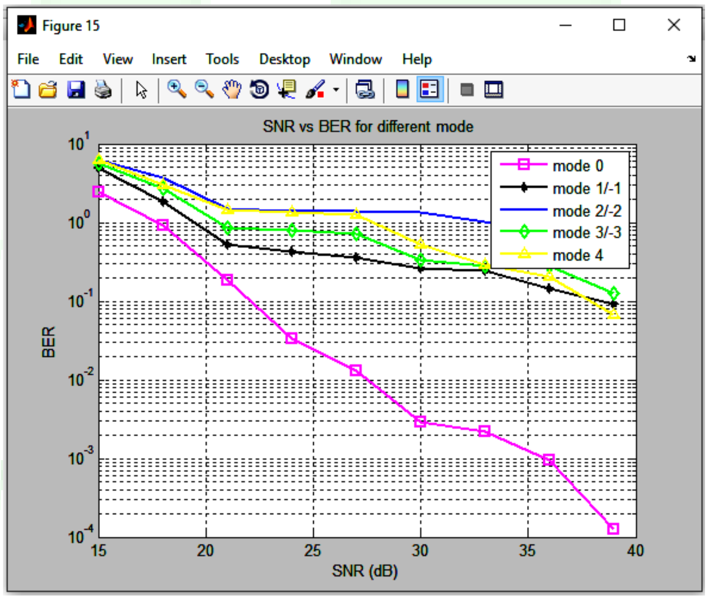

Figure 5.17: SNR vs BER for different OAM mode

Figure 5.17 is showing the output performance in term of signal to noise ratio and bit error ratio for various mode of OAM.

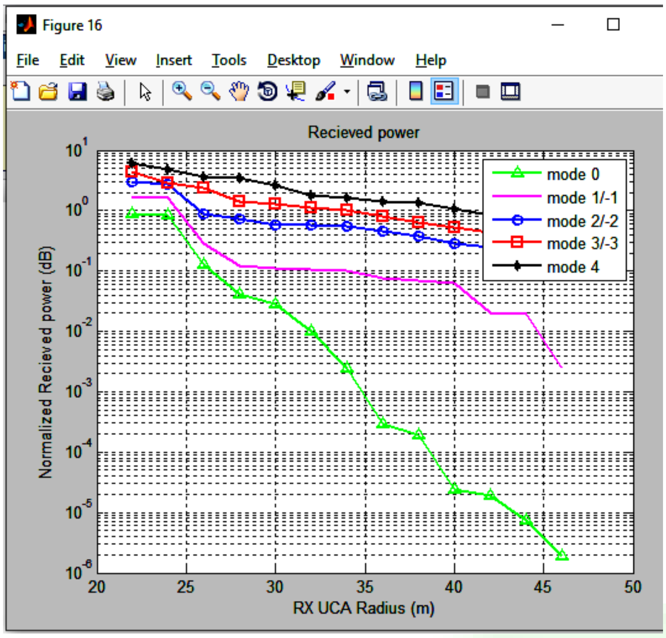

Figure 5.18: Received power

Figure 5.18 is showing the received power of the signal. The normalized received power is 10dB and UCA radius is 47 meter.

Table 5.1: Simulation Parameters

Sr No	Parameter	Value
1	Number of TX antenna	8
2	Number of RX antenna	8
3	Matrix Channel	2
4	Array shape	UCA
5	UCA radius	47 m
6	Modulation Technique	QAM
7	Modulation order	16 and 64
8	Number of Modes	5

In table 5.1, simulation parameters are showing which is taken during the execution of MATLAB script. The array shape uniform circular array (UCA) is taken with maximum radius 47 meter.

Table 5.2: Results comparison of previous vs proposed work

Sr No.	Parameters	Previous Results	Proposed Resul
1	Method	OAM	OFDM-OAM
2	Modulation	Not Mention	QAM
3	Power	-110 dB	10 dB
4	UCA radius	1 m	47m
5	BER	Not Mention	10^{-4}
6	SNR	20 dB	40dB

Therefore proposed work result is showing the improved UCA radius with saving of power consumption. This research is focus on the development of OAM with OFDM for MIMO based system..

V.CONCLUSIONS

Orbital angular momentum (OAM) has attracted considerable attention as a novel solution for wireless communications because its orthogonal modes significantly increase the channel capacity without an additional frequency band. The joint multiplexing between OAM technologies and other modulation techniques has not been thoroughly investigated. This research proposed the orthogonal frequency-division multiplexing-orbital angular momentum (OFDM-OAM) multiple-input-multiple-output (MIMO) system.

However, in the recent researches on OAM wireless communications, the joint multiplexing between OAM techniques and other modulation techniques such as spatial modulation, polarization modulation and orthogonal frequency-division multiplexing (OFDM) are barely considered. Thus, the assessment for system performance of the joint multiplexing technology would be an important issue. The OFDM techniques for treating frequency-selective fading can perfectly multiplex with the OAM technologies; furthermore, both OFDM and OAM can be realized in the baseband by spatial-domain and time-domain IFFT operators.

FUTURE SCOPE

For the future research, a more efficient time sequence needs to be designed to improve the performance loss of the TOO MIMO system in short transmission. Besides, investigation of the solutions for the bandwidth expansion caused by switching and the exploration of the application scenarios of the TOO MIMO system will be the focus. To develop new channel coding technologies to further reduce the BER of the OAM-OFDM transmission system.

REFERENCES

[1] Yamamoto, T. Nishimura, T. Ohgane, T. Tandai and D. Uchida, “Evaluation of OAM Mode Multiplexing Considering Ground Reflection,” 2019 IEEE International Conference on Communications Workshops (ICC Workshops), Shanghai, China, 2019, pp. 1-5, doi: 10.1109/ICCW.2019.8756856.

[2] K. Mofoka, N. Pillay and H. Xu, “Full-Duplex Relaying for Single-Active Mode Orbital Angular Momentum Index Modulation,” 2019 IEEE AFRICON, Accra, Ghana, 2019, pp. 1-5, doi: 10.1109/AFRICON46755.2019.9133744.

[3] Almaiman et al., “Demonstration of using multiple orthogonal spatial modes for channel header information and channel encoding,” 45th European Conference on Optical Communication (ECOC 2019), Dublin, Ireland, 2019, pp. 1-4, doi: 10.1049/cp.2019.0929.

[4] H. Suganuma, S. Saito, K. Ogawa and F. Maehara, “Inter-Mode Interference Suppression Employing Even-Numbered Modes for UCA-Based OAM Multiplexing,” 2019 IEEE Globecom Workshops (GC Wkshps), Waikoloa, HI, USA, 2019, pp. 1-6, doi: 10.1109/GCWkshps45667.2019.9024598.

[5] Li and D. Shi, “A Novel Spatial Three-dimensional Spherical Array Antenna for OAM Waves

Generation," 2019 Photonics & Electromagnetics Research Symposium – Fall (PIERS – Fall), Xiamen, China, 2019, pp. 373-377, doi: 10.1109/PIERS-Fall48861.2019.9021544.

[6] Z. Zhang et al., "A Dual-polarized Dual-OAM-Mode multiplexed Antenna System," 2019 International Conference on Microwave and Millimeter Wave Technology (ICMMT), Guangzhou, China, 2019, pp. 1-3, doi: 10.1109/ICMMT45702.2019.8992853.

[7] H. Jing, W. Cheng, Z. Li and H. Zhang, "Concentric UCAs Based Low-Order OAM for High Capacity in Radio Vortex Wireless Communications," in Journal of Communications and Information Networks, vol. 3, no. 4, pp. 85-100, Dec. 2018, doi: 10.1007/s41650-018-0036-z.

[8] S. SAITO, H. SUGANUMA, K. OGAWA and F. MAEHARA, "Influence of the Number of Uniform Circular Arrays on System Capacity in OAM Multiplexing," 2018 21st International Symposium on Wireless Personal Multimedia Communications (WPMC), Chiang Rai, Thailand, 2018, pp. 268-272, doi: 10.1109/WPMC.2018.8712929.

[9] P. You, S. Li, Z. Xu, R. Zhao, L. Shen and J. Wang, "Design of Logarithmic-Index Fiber for Orbital Angular Momentum (OAM)Transmission," 2018 Conference on Lasers and Electro-Optics Pacific Rim (CLEO-PR), Hong Kong, Hong Kong, 2018, pp. 1-2.

[10] Saitou, H. Otsuka, R. Yamagishi, R. Ishikawa, H. Suzuki and K. Honjo, "Double Multiplicity Exploiting Orthogonal Polarizations of OAM Wave for OAM Communication with Loop Arrays," 2018 Asia-Pacific Microwave Conference (APMC), Kyoto, 2018, pp. 494-496, doi: 10.23919/APMC.2018.8617476.

[11] J. Xu, "Full-Diversity OAM Multiplexing by Antenna Array," 2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, Boston, MA, 2018, pp. 2217-2218, doi: 10.1109/APUSNCURSINRSM.2018.8608860.

[12] G. Zhu et al., "Random Degenerate-Mode-Mixing Independent OAM Mode-Group (De)multiplexing Over a Graded-Index Ring-Core Fiber," 2017 Asia Communications and Photonics Conference (ACP), Guangzhou, China, 2017, pp. 1-3.

[13] G. Ruffato, M. Massari, E. Gazzola, G. Parisi and F. Romanato, "Diffractive optics for OAM-mode division multiplexing in optical fibers," 19th Italian National Conference on Photonic Technologies (Fotonica 2017), Padua, 2017, pp. 1-4, doi: 10.1049/cp.2017.0178.

[14] L. Zhu et al., "Experimental Demonstration of 8.4-Tbit/s Data Transmission over an 18-km Orbital Angular Momentum (OAM) Fiber using WDM and OAM based Mode Division Multiplexing (MDM)," 2017 European Conference on Optical Communication (ECOC), Gothenburg, 2017, pp. 1-3, doi: 10.1109/ECOC.2017.8346128.

[15] T. Nguyen, M. Hirabe, R. Zenkyu, M. Uchida and E. Sasaki, "An experimental study on OAM mode-multiplexing with dielectric lens fed by uniform circular array," 2017 International Symposium on Antennas and Propagation (ISAP), Phuket, 2017, pp. 1-2, doi: 10.1109/ISANP.2017.8228721.

