

Hybrid MIMO-OFDM System for 5G Network Using VLC- A Review

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Abstract—The 5G mobile network promises to be faster and smarter and has lower latency and higher efficiency, lower bandwidth issues compared to 4G. A VLC uses LED for higher data transfer rate wireless communication. Wireless standards in broadband system LTE (Long Term Evolution) and MIMO (Multiple-Input-Multiple-Output) Wi-Fi technology incorporate an increase in antennas create more signal path which increases reliability and performance. This paper reviews the performance of VLC usage for the 5G network using MIMO-OFDM, Massive MIMO, SU (Single-user) MIMO, MU (Multi-user) MIMO and Hybrid MIMO which are optimised using various algorithms and presents a comparison of the techniques as mentioned above.

Keywords— MIMO, OFDM, VLC

I. INTRODUCTION

Hybrid MIMO (multiple input multiple output) is a combination of Spatially Multiplexed (SM) and Space-time block coding (STBC) with OFDM (Orthogonal

Frequency division multiplexing). Spatial multiplexing is a method of transmitting independent ciphered data signals, known as "streams". Hence, the space dimension gets re-utilised or multiplexed more than once. Visible Light Communication (VLC) is a data communication spinoff that utilises region of visible light ranging between 400 and 800 THz (780-375 nm). VLC is based on the concept optical wireless communication technologies where visible light is modulated to transmit data. The article [1] scrutinises the VLC a technology in which perceptible spectrum is attuned to transfer data. It expounds about the VLC communication system: the receiver, the channel and the transmitter. The paper introduces both single-channel and multichannel transceivers. The paper proposes single as well as multichannel transceivers. The article discusses carrier for a system that utilises a single light-emitting diode (LED) and the matrix depicting the multicolour channel. Multifarious modulating schemes, basic techniques used for implementing a

VLC system and assorted causes of dimming get discussed. Also, the paper reviews standardisation of VLC technology, appliances as well as challenges for VLC practical application and commercialisation. The paper [2] presents the technological concept of MIMO wireless communication systems. This article discusses both open and closed loop SU-MIMO systems with appropriate pre-eminence for maximising the data rate of MIMO. A comprehensive analysis of various MU-MIMO downlink and uplink techniques is then followed by elucidating the latent concepts of MU-MIMO in mobile communication systems. In paper [3] OFDM technique for MIMO channels is recommended to curtail inter-channel interference (ICI) elicited by high-speed mobile in a cellular environment. On analysing the ICI evoked using a simple curve fitting methodology by mobile channels of high speed system, the weighting factor gets optimised for group transference. Then, the paper suggests a new MIMO-OFDM method, based on weighting factor optimisation for lessening ICI evoked by channels that are time-varying in nature. The IMETRA channel verifies the performances of the proposed technique, intended for a MIMO channel

to 3 GPP, and a MIMO-OFDM simulator devised for microcellular communication. It is exhibited by computer simulations that the proposed MIMO-OFDM method is efficacious in paring down the ICI and noise and in attaining diversity gain even under highly-associated fast fading channels when compared to the conventional MIMO-OFDM schemes. In paper [9] the perusal provides a sketch of energy-efficient wireless communications, analyses critical and contemporary contribution to the modernisation, and discusses the most conformant research problems for addressing in the future. In paper [13] exponential growth of some mobile users has led to the increasing demand for bandwidth and channel capacity. Thus 5G has to support a new multitude of various mobile applications. The 5G network has not only sufficiency constraints but also current hindrances such as coverage, latency, network reliability and energy efficiency with existing communication systems. Visible Light communication provides broadband wireless data connectivity for high capacity channels. The VLC system utilises intensity modulation, where the information is conveyed through the intensity of LEDs and detected by the

photodiode (PD) at the receivers. This survey paper discusses various techniques for supporting 5G networks using massive MIMO-OFDM concept using visible light technology.

II. LITERATURE REVIEW

VLC BASED MIMO-OFDM: Paper [4] has identified the importance of visible light source for MIMO systems, using LED source and photodiode detectors (PD). Visible light source offer a capacity gain that is connected to the parallel single-input-single-output (SISO) channels and also attractive in usage. MIMO VLC system enables high SNR (signal-to-noise ratio) of a SISO channel. This is due to their distinct lighting property necessity for surmounting the capacity limitation in maintaining the modulation bandwidth of LEDs. This research has proposed VLC (SVD-VLC) MIMO which is an altered singular value decomposition system. This (SVD-VLC) MIMO system maximises the rate of data simultaneously conserving the intended illumination and authorising to support for mobility to the channel matrix in a realistic indoor deployment of VLC. The upper bound capacity on the suggested SVD-VLC MIMO system is computed on the assumption of an imaging transceiver.

The paper describes the relationship among the suggested system effectiveness and system specification, lens aperture, total power constraint and random receiver locality. Using LEDs, the potential visible light communication (VLC) data rates are found in range about 10 Gb/s in recent times. However, LED has a disadvantage in terms of its built-in trade-off between bandwidth and optical efficiency. Hence, laser diodes (LDs) can be an assuring substitute of VLC. The research emphasises on the off-the-shelf LDs communication capabilities with lighting constraints. The outcome has indicated that the data rate of optical wireless can exceed 100 Gb/s and it can be attainable at average indoor radiance level [5] The paper [6] has recommended ICA that stands for Independent component analysis (ICA) that is based on the MIMO-OFDM VLC scheme, where ICA is performed to transform the MIMO-OFDM channel into its numerous SISO-OFDM channels. This can lead to lower computational intricacy in terms of channel estimation, with none of the spectral overhead. Frequency modulation (FM) is first introduced to modulate the OFDM symbols in order to eliminate the interrelation of the signals, so that the performance of ICA algorithm

could be modified. In the 4*4 MIMO-OFDM VLC experiment, simulating both LOS and NLOS paths are given due consideration, where each transmitting 100Mbps signal. The paper claimed that the proposed scheme reached 10^{-5} level at SNR=20dB. The result achieved a significant enhancement in comparison to old schemes. In the paper [7], it conducts a brief survey of the most recent advances and research activities in OWC. It studies the advantages and potential applications of OWC and provides an overview of the techniques used to achieve directions for OWC also gets discussed. The paper [8], asserts a generalised LED (light emitting diode) for the index modulation design of MIMO-OFDM VLC systems. The new scheme generalises the index modulation approach of LED with the concept of spatial multiplexing principle in order to transmit complex OFDM signals via VLC channels. This is activated by dichotomising these signals into their real-imaginary and positive-negative parts. A posterior (MAP) estimator of the contemplated scheme can achieve better error performance as compared to the current VLC-MIMO-OFDM systems due to its enriched transceiver structure and power efficiency. The survey in [9]

scrutinises the energy-efficient wireless communications, summarises crucial and contemporary contributions to the cutting-edge technologies and converses about the most relevant research challenges for getting attended in the future. The paper [10] empirically tests each of the SVD-based adaptive loading and OCT precoding to improve sufficiency of the MIMO-OFDM VLC systems. For transmission of 1.5- Gbit/s/m, the average BER can get abated from $1.7*10^{-2}$ to $4.1*10^{-3}$ and $4.7*10^{-4}$, respectively. In the paper [11] the authors have asserted an algorithm for adaptive channel estimation for asymmetrically clipped system of optical OFDM-VLC and evaluated its optimal SNR threshold via simulated analysis. The recent scheme for estimation incorporates the positive aspects of discrete Fourier transform of least-square algorithm and orthogonal matching pursuit algorithm. It is sinewy to change in SNR range and channel distribution. The encoded BER and the mean square error (MSE) present the effectiveness of the VLC system using 16-QAM. The scheme proposed can ameliorate the MSE more than 10dB in the high SNR range. Paper [12] deals with the information state of the channel which is also known as

transmitters. The paper considers a general criterion for the trade-off between error performance and spectral efficiency that is established by analysing the unique parameters of MIMO-VLC. The paper has recommended a modulation system called channel-adapted spatial modulation (CASM) after the consideration of criteria for massive MIMO-VLC to determine the perfect combinations of active LEDs under the controlled ICI. The simulation results have showed that CASM actualises have more BER gains over the optical multi-stream spatial modulation (OMS-SM). The spectral efficiency was marked up to 10% reduction caused by CSI update. Moreover, more gain in CASM over OMS-SM is achievable at higher spectral efficiency. In paper [14] the discussion is about the massive MIMO-VLC system where optimisation is performed for the reduction of overall channel matrices. A formulation for combined optimisation problem to detect symbols using minimum symbol error rate criterion and to optimise the exponent. The simulation results shown in the paper has proved superiority of the BER performance for the proposed technique of adaptive precoding technique when compared to existing methods. Additionally, the paper derived and

validated the BER's analytical upper bounds through simulations. In paper [15] next-generation technologies are being tried to develop for 5G wireless cellular networks nowadays by many researchers. Some of the key technologies provide significant improvements for 5G systems regarding huge capacity, higher data rate, signalling overhead on the network and energy-spectral efficiency etc. But these technologies also bring along critical challenges for 5G systems. In this study, these significant challenges of 5G networks get discussed concerning scarcity radio frequency (RF) spectrum, inter-antenna synchronous, and antenna deployments in cells, network and traffic management, cost and workload. Also, these challenges get expressed, presented and discussed in each section to provide prior knowledge and perspective for 5G network designers and researchers. In paper [16] The MIMO methodology is utilised in VLC for increasing the data rate. This article conceives a general solution of controlling the brightness and MIMO transceiver design for VLC for minimising the mean square error between the signals transmitted and signals received, simultaneously controlling the indoor lighting at a specific level. The paper

considers the optical constraints in the practical design such as LED dimming requirements and its non-linearity properties. Effective solutions for the design problem are derived by the help of projected gradient algorithm. From the results, the conclusion is that BER performance is better with a significantly higher convergence speed. The need for analysis of beamforming architectures arises to study their peak-to-mean power envelope ratio w.r.t antenna elements and its total average transmission power constraints upon the multi-beam transmissions. It shows that utilisation of important normalisation coefficients are necessary for hybrid beamforming architecture to achieve the average transmission power within the net power constraints. The simulation results have showed efficacy of the multi-beam transmission diversity against single-beam analog beamforming with the consideration of a complete power normalisation for the composite beamforming formation with a shared array of antenna [17]. The overview in [18] discusses the OFDM evolution. The improvement of effective multicarrier OFDM arrangements with MIMO system has abundant advantages. The article

highlights the drawback of traditional detection and channel estimation techniques conceived for the multiuser MIMO-OFDM systems. In this the number of supported users and the antennas have exceeded the receiver antennas. This mismatch in antennas is a practical situation which can be controlled by restricting access of the users to connect with the coverage area of the base station. The paper also gives details of classic multi-user detectors (MUDs) designed for MIMO-OFDM system and characterises the possible operation. Another objective in this paper is the genetic algorithm (GA) aided detector solutions, where it reviews principles of GA-assisted optimisation methods, which got proposed recently for MU-MIMO-OFDM for simulating the cross-pollination of ideas between optimisation, wireless communication, Machine learning and signal processing. The author also noted that the method is capable of giving a near-optimal performance but only at a somewhat lower complexity in computations as imposed by the maximum likelihood of MUD aided counterparts. The paper [19], carries out the analysis for the performance of ICA MIMO-OFDM VLC system using various photodetectors with the same field of view

(1-FOV) and two different fields of view (2-FOV). The use of MIMO has led to the complexity of channel estimation and forming a complex channel matrix. In order to convert MIMO-OFDM signals and to reduce the complexity, ICA is applied into SISO-OFDM signals. To minimise the peak-to-average power ratio (PAPR) of an OFDM signal, frequency modulator is used and it also diminishes the interrelation between the MIMO-OFDM signals and at the same time boost the separation efficacy of ICA. Simulating the 4 by 4 MIMO-VLC indoor environments, the results have showed the BER to be approximately 0.0001 level at SNR of 12 dB with 2-FOV optical receivers. It has proved to be more appropriate than traditional 1-FOV optical receivers. Through minimum mean square estimation (MMSE), the BER is found approximately 0.00001 level at 12 dB SNR and it is better as compared to the least square estimation (LSE). In paper [20], a discrete Fourier transforms spread orthogonal frequency-division multiplexing (DFT-S-OFDM) has exhibited with its enhanced performance in lowering the peak to average power ratio (PAPR) simultaneously sustaining reliable transmissions. The paper has also explored the DFT-S-OFDM technology application

in VLC and explained the mechanism effect of multiple lighting distributed layout on the overall performance. Besides the proposal of an optimisation process of lighting scheme, a trade-off is maintained between the maximum delay spread and strong interfered areas inside. Finally, a diversified lighting VLC downlink prototype based on a Gbit/s DFT-S-OFDM is achieved for the first time in the form of a compact size component in the real-time baseband modem. For wireless communication, optical wireless communications (OWC) is an upcoming promising technology with limitation of capacity in the range of radio frequency (RF) spectrum. VLC has an excellent opportunity for communication of short-range outdoor vehicular system as LED lights can also transmit data. But the outdoor VLC channels alter the reflection resulting in time domain scattering and its fast and encountered multipath dispersion. Outdoor VLC links are obstructed by high levels of environmental noise, especially from the sun. OFDM gets deployed in VLC links since it is robust to multipath fading and noise effects. In paper [21], optical OFDM (O-OFDM) with an adaptive modulation scheme are examined in VLC for the vehicle to vehicle

communications. A (2*2) MIMO channel is considered, with many reflections and interference such as sunlight. A through study of asymmetrically Clipped Optical OFDM (ACO-OFDM) and direct current biased optical OFDM (DCO-OFDM) was performed.. Simulated results for the envisaged model has shown a spike in data rates which is up to 50Mbps with an effect of diminished bit error rate (BER) under the line of sight (LOS) noise infected conditions and non-LOS. In paper [22] VLC is used as a model for an actual outdoor optical channel and further proposing STBC-OFDM to abate the effect of extreme optical multipath dispersion that is related to a similar mock channel to achieve useful BER of 10^{-6} even if SNR is low. Considering the case, the prolongation of optical signal transmission distance gets maximised. From the results of STBC-OFDM and SISO counterparts in BER comparison performance, VLC-ITS system has shown distinct performance using STBC-OFDM technique due to the multi-path scattering mitigation. The paper [23] provides the spatial coverage potential of a vision sensor for implementing a dual service system to a museum security purpose. The system is efficient in handling MIMO

visual communication and object monitoring. The Kalman filter algorithm is used for monitoring the objects. For implementing ARC (adaptive row column) based least significant bit substitution technique, a secret visual MIMO communication, is combined with integer wavelet transformation method. These services are applied by utilising surveillance camera and an existing electronic visual display. The tests are conducted with a sample object and four stego images. The pursuance of the object tracking system gets weighed concerning accuracy by correlating the factual and predicted object position. Likewise, the efficacy of the visual covert MIMO system gets estimated at dual stage level. For measuring the imperceptible segments on side of the transmitter side, differences between stego-images and cover images were utilised. Similarly, in the receiver segment, differences between reconstructed and original data images are utilised for accuracy measurement. The results allegorise that the system proposed has enhanced accuracy, robustness and imperceptibility compared to existing methodologies. The letter [25] documents an empirical exposition of the high-speed indoor optical wireless MIMO-OFDM

system with an imaging receiver. The system comprises of a 2×1 array of white LEDs that can transfer information for a 9-channel imaging receiver using a 3×3 array of photodetectors. The paper achieved a net transpondence rate of 220 MBps at a bit error rate of 0.001 over a range of one metre. An experimental setup of a optical design and an outline of the design requirements,, are reported in this letter, along with results and discussion of the system's achieving improvements. The paper [26] provides the latest accomplishments and furore in high-speed indoor VLC research. The paper addresses the future visions and the potential applications for VCL technology, where conveying the information is "piggybacked" on the lighting function of LED-based lamps. For improvement, the research is carried out on real-time implementation and trials. It presents a bidirectional real-time VLC prototype which achieves data rate to the maximum of 500 Mbps thereby paving the way for real-world applications. Paper [29] researches about the hybrid LTE and VLC networks performance using VLC as the onboard access network and LTE as the backhau. The proposed configurations based on their (DCO-OFDM) get

compared concerning their BER performances. Additionally, the efficacy of intravehicular VLC networks gets investigated for both single and multi-user scenarios. In paper [30] hybrid transceiver can strike a balance between complexity and performance of MIMO systems. This paper developed a unified framework on the design of hybrid MIMO transceiver using matrix-monotonic optimisation. The proposed framework addresses general hybrid transceiver design, rather than just limiting to certain high-frequency bands, such as millimetre wave (mmWave) or terahertz bands or relying on the sparsity of some specific wireless channels. In the proposed framework, analog and digital parts of a transceiver, either linear or non-linear get jointly optimised. Based on matrix-monotonic optimisation, the paper demonstrates that the combination of the optimal analog precoders and processors are equivalent to Eigen channel selection for various optimal hybrid MIMO transceivers. From the optimal structure, several useful algorithms are derived to compute the analog transceivers under unit modulus constraints. Further to reduce computation complexity, a simple random algorithm gets introduced for analog transceiver optimisation. When the analog

portion of a transceiver is determined, it obtains the closed-form digital part. The advantages of the proposed design get verified with numerical results.

III. PROPOSED SYSTEM

The paper [24] discusses an important issue of OFDM which is high PAPR of the transmitted signal that unfavourably affects the intricacy of power amplifiers. Many assuring approaches have been contemplated and actualised for reducing the PAPR of OFDM signal with an This paper has executed selective mapping (SLM), partial transmit sequences (PTS), clipping and filtering, peak insertion (PI), and linear block coding (LBC) methodologies for PAPR reduction of OFDM signal at the transmitter. Comparison among these techniques is carried out by recording system's CCDF and BER performance. The paper concludes that peak reduction technique is most effective in PAPR reduction. In paper [27] Visible Light Communication is an innovative and active technique in modern digital wireless communication. A new innovative and active technique in this paper. This paper describes a new innovative VLC system which has better performance and efficiency compared to

other previous systems. The paper uses MIMO with OFDM technique which enhances the data rate of wireless data transmission. Since the multiple transmitter and receiver have different links distances, having different temporal delays, complex channel gain and phase differences are resulting when frequency domain have transformed. In OFDM each subcarrier, the calculation of the corresponding pre-coding matrix in the frequency domain for the elimination of multiple interferences. The paper first considered phase information in the frequency domain where precoding uses complex matrices, real, channel matrices which gets used for reducing the channel correlation to achieve better performance. This paper describes a detailed survey of the VLC system and characteristics of transmitter and receiver, modulation methods, SISO, MIMO, MIMO_OFDM, VLC sensing and applications, VLC system architecture design and programming platform. The paper studies different methods for VLC system. MIMO-OFDM used in this system considers the phase differences in channel matrices in the light frequency domain that gets induced by the distance differences between the multiple transmitter and

receiver links. This paper designs the signal surface using OFDM and creates a distance between surfaces. It also adjusts the incident angle of the light beam which enters an optical tube. Paper [28] has presented the effectiveness of spatial multiplexing, image transportation with STBC, and hybrid MIMO with OFDM models. The performance of the models as mentioned above gets computed concerning BER and throughput and output image quality. Results showed that characteristics of Hybrid MIMO-OFDM have low BER with high throughput. Vehicular hotspots for onboard network access using LTE as the backhaul network are the latest development. Wi-Fi is a prominent technology for providing in-vehicle access, which is connected with an LTE receiver. In spite of coexistence, wide acceptance and contention-based data rate limitations with Wi-Fi, it compels for alternatives in-vehicle data access schemes. This paper tests the performance of VLC networks and hybrid LTE with the help of VLC as an onboard access network and LTE as backhaul. Considering the unique channel characteristics, vehicle interior,, best transmitter configuration using repetition coding, LED deployment flexibility and Spatial multiplexing, the

MIMO modes are determined. The proposed configurations based on DCOOFDM are compared concerning their BER performances. Further, the intra-vehicular performances are tested. [29]

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