Performance Evaluation of High Speed Multicarrier System for Optical Wireless Communication

Harshita Mathur¹, TDeepa¹ and Sophiya Bartalwar¹
¹SRM Institute of Science and Technology, Kattankulathur, India
deepa.t@ktr.srmuniv.ac.in

Abstract: Optical wireless communication (OWC) in the infrared and visible range is quite impressive solution, especially where radio communication face challenges. Visible light communication (VLC) uses visible light over a range of 400 and 800 THz and is a subdivision of OWC technologies. With an increasing demand for use of wireless communications, wireless access via Wi-Fi is facing many challenges especially in terms of capacity, availability, security and efficiency. VLC uses intensity modulation and direct detection (IM/DD) techniques and hence they require the signals to certainly be real valued positive sequences. These constraints pose limitation on digital modulation techniques. These limitations result in spectrum-efficiency or power-efficiency losses. In this paper, we investigate an amplitude shift keying (ASK) based orthogonal frequency division multiplexing (OFDM) signal transmission scheme using LabVIEW for VLC technology.

1. Introduction

With an increasing demand for use of wireless communications, wireless access via Wi-Fi is facing many challenges especially in terms of capacity, availability, security and efficiency. Recently, “Li-Fi” was introduced by Harald Hass in 2011 on visible light communication (VLC) [1], to overcome those challenges which are faced by Wi-Fi. VLC uses intensity modulation and direct detection (IM/DD) techniques and hence they require the signals to certainly be real valued positive sequences. These constraints pose limitation on digital modulation techniques. These limitations result in spectrum-efficiency or power-efficiency losses. VLC is a data communications medium which uses visible light over a range of 400 and 800 THz and is a subdivision of OWC technologies as shown in Figure 1.

Design and development of new and efficient wireless technologies for a range of transmission links is an important for building future wireless communication networks for providing wide range of services and to satisfy with the ever-increasing demand of achieving higher data rates [2].

Figure 1. Spectrum Analysis for VLC
Software defined radio (SDR) approach has been emerged as a feasible prototyping option for future 5G wireless research by enabling researchers to quickly prototype a system, characterize it’s performance, on the design[3]. For flexibility of communication in optical system on off keying (OOK) technique is generally preferred. However it suffers disadvantage of poor bandwidth efficiency and high sensitivity to dispersion for high data rates [4]. Both amplitude and phase modulation renders the prospect of multiple symbol values although the former places challenging demands on laser phase noise. Orthogonal frequency division multiplexing (OFDM) has been adopted as the multicarrier modulation technique offering many advantages such as high spectral efficiency, noise, inter-symbol interference (ISI), multipath robustness and has ability to resist channel fading[5]. OFDM have been adopted for communication in both wireless and wired systems such as: Digital Subscriber Line (DSL) and digital video broadcasting (DVB) systems, Power Line Communication (PLC), Wireless LAN (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), Long Term Evolution (LTE) [6]-[9]. This scheme is an efficient multicarrier transmission scheme works over a wideband channel consisting of overlapping orthogonal narrowband subcarriers for conveying any sort of information which is parallel in the frequency domain.

In this work, amplitude shift keying (ASK) based OFDM transceiver is implemented using LabVIEW. The conventional theory simulation lacks the interference information of practical channel. This paper combines the simulation theory and physical research platform to evaluate OFDM link performance using LabVIEW. The remaining section is structured as follows: section 2 presents ASK modulation. Design of OFDM transceiver using LabVIEW is illustrated in section 3. Section 4 depicts the simulation results. The experimental evaluation of OFDM based VLC is presented in section 5. The conclusion is presented in section 6.

2. ASK Modulation

ASK is a modulation that represents the data in digital form which is obtained by variation in carrier wave amplitude. The M-ASK modulated OFDM signal can be expressed as [10]

\[ x(t) = \sum_{k=0}^{N-1} A_k \cos \left( \frac{2\pi k t}{2T} \right) \]

where \( A_k \) is one of the M-ary amplitudes

\( N \) is the number of carriers and \( \frac{1}{2T} \) represents the subcarrier spacing

3. OFDM System Model in Lab VIEW

The model of OFDM transceiver is shown in Figure 2a and Figure 2b. The data symbols are modulated by means of an inverse fast Fourier transform (IFFT) on \( N \) parallel subcarriers. In order to avoid the intersymbol interference (ISI) and preserving orthogonality between subcarriers the cyclic prefix (CP) is appended in IFFT output symbol to form the complete OFDM symbol. The resulting OFDM symbol is serially transmitted over a discrete time channel. At the receiver, the data are retrieved by means of a fast Fourier transform (FFT). Finally, the data is being de mapped after a serial conversion and finally retrieved back at the output. Complete implementation and simulation is conducted in the LabVIEW software environment.

3.1. Procedure for Simulation of ASK based OFDM Transmitter as follows:

- Initialize the number of transmitting bits and ASK map locations
- Generate 10000 bits of pseudo random input bits
- Map bits 10000 bits to 2500 symbols using 16-QAM
- Divide the array of symbols into 20 sets of 125 point data sets and build OFDM symbols
- Insert one of 25 reference symbol after every 21st data symbol 150 pts per OFDM symbol
- Insert 53 zeroes at the edges of the passband
• Perform an Inverse FFT to convert the frequency domain design to a time domain signal obtaining 256 point IQ time domain waveform
• Insert a 64 point CP by duplicating the last 64 points of the array at the beginning resulting in 320 point IQ time domain waveform
• Generate frequency representation of OFDM signal.

3.2. Procedure for simulation of ASK based OFDM receiver as follows:
• Remove the CP.
• Compute the FFT convert in the time domain symbol to the frequency domain.
• Remove zero padding.
• Convert data symbol mapping back to data bits.

4. Simulation Results and Discussion

![Figure 2a. ASK OFDM Transmitter in LabVIEW](image-url)

To analyze the performance of ASK based OFDM transceiver, the following simulation parameters is considered as shown in table 1.
The implementation of 16-ASK based OFDM transmitter and receiver is shown in Figure 3 and Figure 4 respectively. The estimated result with simulated output is obtained both for 16-ASK transmitter and receiver. With 10 000 transmitted bits and 256 subcarriers with 4 bits per symbol the ASK constellation diagram along with frequency representation for OFDM symbol after CP is obtained for transmitter. With IQ rate of 10 M, bit error rate 0.12 is obtained and the output for frequency representation for OFDM symbol after CP removal, transmitted symbol before equalization and equalized symbols is plotted.
5. Experimental Setup for Implementation of ASK based OFDM

In ASK modulation the 16-ASK based OFDM signal is extracted from PC and inserted in MAX 232 IC in square bit form. The hardware setup and experimental setup for ASK OFDM based VLC is illustrated in Figure 5. This square bit form modulation converted to frequency mode by MAX 232 IC for controlling the output and amplifying signal an amplifier negative is manufactured using NPN IC and amplifies negatively. Finally, for ASK modulation (the conveying of signal through light). For this process 12 LED’s are employed which is derived negatively according to modulation , according to modulation the intensity of light glowing by LED varies and this variation is grasped by light dependent resistor (LDR) sensors which is fitted in opposite side of LED is closed pack covered with black paint in order to prevent external light effect. LDR varies resistance value according to modulation of several frequencies.This variation is connected directly to microcontroller and with external programming to microcontroller extracts output from several ports and pin which is directly connected and negatively derived for display unit. This display unit is made by light emitting diode (LED) light modulating process.
6. Conclusion
In this paper, we have probed the ASK based OFDM for VLC system. The 16-ASK transmitter was simulated to obtain the desired modulated waveform, at the receiver output and the plot of FFT response were demonstrated with BER performance traits. The work was further broadened by associating this OFDM with MAX232 IC and microcontroller which passed through digital to analog converter, the transmission was made through LED, the receiver had LDR and finally the communication has been accomplished via LED. With this hardware implementation one can prove that ASK modulation process is mainly used Telecommunication purpose for conveying the vocal convention can be transmitted through lighting process with high speed and which can be conveyed to optical system.

Figure 5. Experimental Setup for Implementation of ASK based OFDM

7. References
[1] Hamidović D and Suljanović N 2016 Development of the generic OFDM based transceiver in the LabView software environment 39th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), Opatija, pp. 581-586.
[2] Zhang D F, Zhu Y J and Zhang Y Y 2013 Multi-LED Phase-Shifted OOK Modulation Based Visible Light Communication Systems IEEE Photonics Technology Letters, 25, pp. 2251-2254, Dec.1, 2013.
[3] Abbas Kattoush 2010A Novel Radon-Wavelet Based OFDM System Design and Performance Under Different Channel Conditions International journal of arab information technology, /Vol. 7.
[4] Elgala H, Mesleh R, Haas H and Pricope B 2007 OFDM Visible Light Wireless Communication Based on White LEDs *IEEE 65th Vehicular Technology Conference - VTC2007-Spring*, Dublin, pp. 2185-2189.

[5] Prabakaran P M, Sivasubramanian A, Jawahar A, Chitra K 2016 Performance Analysis Of Wavelet Packet Transform Based De-Noising Receiver For Visible Light Communication By Using Single Source *International Journal Of Engineering Research In Africa*, 20, Pp. 195-201.

[6] Agiwal M, Roy A and Saxena N 2016 Next Generation 5G Wireless Networks: A Comprehensive Survey *IEEE Communications Surveys & Tutorials*, vol. 18, no. 3, pp. 1617-1655.

[7] Fuqin Xiong, 2003 M-ary amplitude shift keying OFDM system in *IEEE Transactions on Communications*, vol. 51, no. 10, pp. 1638-1642.