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A Wavelet Based Optical Wireless System Based on OOK Modulation-An Overview

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Abstract: High-speed wireless optical communication links have become more popular for personal mobile applications. This is a consequence of the increasing demand from the personal information service boom. Compared to the radio frequency domain, optical wireless communication offers much higher speeds and bit rates per unit power consumption. This work presents the use of wavelet transform and artificial neural network as elements of optical wireless communication receiver. Indoor wireless links usually have to operate in presence of noise generated by light sources. The work uses the MATLAB tool for providing effects of Inter-symbol Interference and light interference on this receiver. In this, modulation technique OOK is used. The performance of this system is analyzed based on BER value.

Keywords: Artificial neural network (ANN), optical wireless communication (OWC), wavelet transform, survey papers.

I. INTRODUCTION

[1] Communication is one of the important aspects of Life. Previously various methods like sign languages were used for this purpose. With the advancement in age and its growing demands, there has been rapid growth in the field of communications. By the turn of 19Th century, a great leap in the field of communication was observed. Signals, which were initially sent in analog domain, are being sent more and more in digital domain now Today's society is becoming increasingly dependent on wireless connectivity with continuously converging technologies.

The increasing demand for bandwidth had driven researchers to explore new technologies to accommodate more data throughput over the decades. Optical wireless communication attracted considerable attention from the academic community. Starting from short distances and low speed experimental links, the optical wireless communication domain became a viable addition to communication systems, and showed promising prospects. Optical and wireless access networks were originally developed for different communication scenarios.

Optical networks aim to provide long distance, high - bandwidth communications while wireless networks aim to provide ubiquitous, flexible communications mainly in community areas. Various kinds of optical and wireless access network architectures have been proposed and deployed as solutions for access networks separately Optical wireless communication (OWC) is an alternative solution that provides safety for healthcare system. Optical wireless is safe for electro medical devices and is proposed to be employed for healthcare services. For wearable health monitoring, optical sensor technologies are being investigated. Furthermore, optical wireless communication provides some advantages such as high speed data rate, ease of installment low cost front ends, license free operation, and high security. The free space optical wireless link mainly been applied in short range and inter building data connections complementary to existing RF networks. Although challenged by several competitive RF bands, including the industrial, scientific and medical (ISM) radio bands, and the local multipoint distribution service (LMDS) bands, optical wireless showed the promising features of higher data throughput and immunity to the interference usually suffered by RF systems. The origin of optical wireless communication can be traced back to ancient times when fire beacons were used to transmit simple message over long distances. It was the pioneering research work done by F.R. Gfeller and U. Bapst in 1979 that inspired the technical community to explore further the potential of the indoor optical wireless communication.

In comparison to RF, optical wireless communication enjoyed benefits such as: lower implementation cost, higher security, unregulated spectrum and operational safety. On the other hand, the channel can be severely interfered with by background noise: shot noise induced by the background ambient light (radiation from the sun if the system operated near a window or outside) and the interference induced by artificial light sources. IR systems can suffer from multipath distortion (in a diffuse system). Despite of its good attributes that an optical wireless system has as one of the higher speed wireless system, although it is weather dependent as well. In temperate region fog and snow are the limiting factors in this regard. In tropical region, however, rain and haze are other factors limiting FOS performance .The multipath induced inter symbol interference (ISI) and fluorescent light interference (FLI) are the two most important system impairments that

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affect the performance of indoor optical wireless communication systems.

Indoor Optical Wireless System

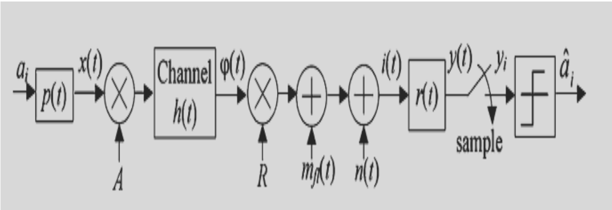

Figure 1: Block Diagram of the Unequalised OOK-NRZ system

Optical wireless communication systems consisted of a transmission unit and a receiving unit. In the transmission unit, a light emitting source (LED or LD) was modulated by a time-varying electrical current (EC) signals generated from the system input. In the receiving unit, photodiodes (PIN or APD) were used to generate EC signals according to the instantaneous optical power received from the EC signals of the transmission. Amplifier and filter modules were also used in both units to improve the system throughput and immunity to noise. The induced inter-symbol interference (ISI) causes a significant optical power penalty (OPP), which increases exponentially with the data rate (or the delay spread). For example, the un equalized OOK modulation scheme incurs a large OPP (dB) at a normalized delay spread of. OPPs would be higher for other modulation schemes with narrower pulse duration such as PPM and DPIM; hence, un equalised reception is not feasible at high data rates for a dispersive channel. Due to the physical properties of the link, most optical wireless systems employed intensity modulation and direct detection (IM/DD). It showed a typical Infrared link using IM/DD. X (t) represents the instantaneous optical power from the emitter, Y(t) indicates the instantaneous current generated by the photo-detector. Since the surface of the photo-detector was millions of square wavelengths at the received optical signal wavelength, the optical link will not suffer from multipath fading effects that usually experienced by the RF system. Transmission & Reception with IM/DD According to transmitter and receiver calibration, the optical link can be classified as LOS or diffuse (non-LOS). In LOS links, the transmitter and receiver were aligned to give the maximum power efficiency. Compared to the diffuse system, LOS offered higher transmission speed due to the lower path loss and narrow field of view (FOV) of the optical receiver. The LOS system can also be deployed in outdoor applications. The major drawback of LOS systems was that they were susceptible to physical blockage of the established links, and thus difficult to apply in mobility situations. Non return-to-zero (NRZ) OOK format is the most popular and widely utilized digital baseband modulation scheme for OWC systems in which binary “1” is represented by transmitting a pulse of duration Tb=1/Rb ,where Rb is data rate and binary “0” by an empty slot of duration Tb. The diffuse link, on the other hand, can provide more robustness for the optical channel at a cost of reduced power and bandwidth efficiency. The transmitter and receiver in a diffuse system established a connection by reflecting light from the ceiling or other diffusely reflecting surfaces. The users of a diffuse system need not consider the alignment between transmitter and receiver. A constant connection can be maintained, as long as the user was covered by the transmitter signals illumination.

Application of wavelets for wireless transmission

The wavelet transform holds promise as a possible analysis scheme for the design of sophisticated digital wireless communication systems, with advantages such as flexibility of the transform, lower sensitivity to channel distortion and interference and better utilization of spectrum. Wavelets have found beneficial applicability in various aspects of wireless communication systems design including channel modeling, design of transceivers, data representation, data compression, source and channel coding, interference mitigation, signal de-noising, energy-efficient networking gives a graphical representation of some of the facets of wireless communications where wavelets hold promise.

Advantages of ANN Equalization

Parallel processing, Universal approximates, No assumptions are made on the channel model, or modulation techniques, Adaptive processing, Channel non-linearity: not a problem.

II. RELATED WORK

The performance(Georgia et al., 2009) [2] of diffuse optical wireless systems, employing Space Time Block Coding (STBC) techniques, is numerically investigated, accurately taking into account, the indoor channel impulse response and the characteristics of ambient light and thermal noises at the receiver. Discrete Multitone modulation (DMT) is used to mitigate the effect of intersymbol interference due to the channel’s impulse response. The network [3] throughput gain in FiWi network subject to peer-to-peer communications and parameters which can affect the network throughput gain. We first have a fair modeling of FiWi networks and traditional WMNs. We then present an LP based routing algorithm for FiWi networks. Extensive simulations have been carried to study the network throughput gain in FiWi networks subject to peer-to-peer communications compared with traditional WMNs. The work provides insightful observations for fully utilizing advantages brought by the integration of PONs and WMNs in FiWi networks. By sending peer-to-peer communication traffic from one wireless client to its closest ONU through wireless sub network, which is then sent to the ONU close to the peer wireless client through PON sub network and then delivered to the peer wireless client through wireless sub network again, the interference in wireless sub

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network can be sustained, thus, network throughput can be improved. The investigation [1] of the DWT-ANN- based receiver for baseband modulation techniques including OOK, pulse position modulation, and digital pulse interval modulation. The proposed system was implemented using digital signal processing board and results were verified by comparison with simulation data. The multipath-induced inter-symbol interference (ISI) and fluorescent light interference (FLI) were the two most important system impairments that affected the performance of indoor optical wireless communication systems.

A multiple-input and multiple-output indoor wireless[4] optical communication system with fixed-length digital pulse interval modulation (FDPIM) has been developed in this paper. The system has 1080Mbit/s data rates with eight channels, does not need symbol synchronization and has fixed symbol length. It is also analyzed the symbolic structure, bandwidth, error rate characteristics and other aspects of FDPIM system. We compared it with OOK, PPM and DPIM modulation system, the result shows that the system is batter to meet the requirements of low-cost and high data rates of the indoor wireless communication system in the following years. Some authors [5]was a study on the effect of reflected light on optical code-division multiple-access (CDMA) system over indoor optical wireless communication (OWC),Bit error rate (BER) of this system was analyzed considering reflected light, background light, avalanche photo-diode (APD) noise, thermal noise, and multi-user interference. The results proved that the BER of the system is influenced by the reflected light and the effect of reflected light was related to the room size and receiver position. Some author [6] Provided the in depth discussion and analysis on the design and performance of MIMO system based on a 2×2 infrared OOK modulation and regulated at 100 kHz, 1 MHz and 10 MHz bandwidth. This described the advantages of an OOK based infrared MIMO system through evaluating the BER performance, and making comparisons of the SISO system, the diversity and multiplexing gain processes.

An indoor optical wireless communications [7] using adaptive wireless optical transmission scheme for health monitoring system. In this scheme, optical wireless communication was proposed to transmit the obtained measurements from sensors to a central node and a medical centre using intensity modulation direct detection (IM/DD) with on-off-keying (OOK) modulation. The analytical results indicated that by employing the adaptive transmission scheme, the required SNR of 13.6 dB was achieved. Some authors [8] proposed partial pre-equalization for indoor optical wireless transmissions based on asymmetrically clipped optical orthogonal frequency division multiplexing (ACO-OFDM)with intensity modulation and direct detection (IM/DD). Bit loading is applied to minimize the transmit optical power for a fixed target BER. comparison to pre equalization, partial pre-equalization can still offer a significant reduction in the required transmit optical power over post equalization, while being applicable in a wider range of practical situation.

Based [9]on a realistic indoor channel conditions, we apply NOMA to indoor VLC channels and demonstrate its superior performance over orthogonal frequency division multiple access (OFDMA).for a realistic indoor channel model with illumination design constraints, the superior performance of NOMA over conventional OFDMA scheme has been demonstrated. Although, the receiver complexity can be seen as a drawback for NOMA, the return is considerable.

An indoor optical wireless multiple input multiple output(MIMO) [10] system with a non imaging receiver. The system setup consist of 2*2 array of white light emitting diode (LED) with spacing 15 cm and a 2*2 photo detector array with 10cm spacing. A bit error rate of 8 Mb/s/channel was achieved. The transmission rate of a single LED is constrained by the low ignals to be recovered. bandwidth (~2MHz). MIMO technique allows parallel transmitter. Some authors [11] proposed the bit error rate (BER) performance of multiple-input multiple-output underwater wireless optical communication (MIMO-UWOC) systems. In addition to exact BER expressions, we also obtain an upper bound on the system BER. To effectively estimate the BER expressions, we use Gauss-Hermite quadrature formula as well as approximation to the sum of log-normal random variables. Moreover, we approximated the weighted sum of log-normal random variables with an equivalent log-normal random variable to reduce M × N- dimensional integrals of averaging (over fading coefficients) to one-dimensional integrals.

III. PROBLEM FORMULATION

The ISI caused by multipath propagation and artificial light interference from fluorescent lamp driven by electronic blast are two major interferences, and these need to be taken into account when validating modulation schemes. The main challenge faced by this work is to seek the most optimized modulation scheme that can provide maximum system throughput while capable of withstanding most if not all of the intense channel interferences at a target BER requirement. Bandwidth efficient schemes such as the OOK and PPM are prone to artificial lighting interferences. This led to a natural conclusion of a modulation scheme that can combine benefits from both above candidates and able to avoid the drawbacks of each individual scheme.

The sunlight and incandescent light exhibited less periodic characteristics than the florescent light. Thus an optical filter can be used to effectively block much of these two types of radiation. The noise source of wireless link along with performance of frequency and alteration are the major factors for finding the performance of system. The evaluation of noise at input of receiver is serious in all links of communication. It is the location where power of input received signal is least. Noise is produced because of presence of random movement of carriers in different types of devices. The noise is produced due to thermal effect due to presence of resistive elements in amplifying stage of receiver. So, in this work, ANN-based receiver for

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modulation technique including OOK is proposed. The main objective of this work is to explore the system using ANN and wavelets. Better BER performance can be obtained by designing the system modulation/demodulation to achieve a higher average BER first, and then reducing the results to the target BER value through ANN receiver. In this, CWT acts as a pre-processing element of neural network and considered the performance of such architecture. Indoor systems suffer performance degradation due to effects of intense light from natural and artificial source. In this, artificial light source induces periodic interference that contains harmonics of switching frequencies of their electronic circuits. These periodic signals have the potential to impair link performance. A common technique is to use high pass filtering to remove interfering signals. Although filtering may be effective at attenuating the interference, it introduces amount of ISI in system.

The communication in indoor systems suffers degradation in performance because of presence of effect of interfering light from natural source and artificial source. The average power of radiations in background is defined as a white Gaussian noise signal. Some modulation techniques are working well in electromagnetic channels or systems but it is not necessary to perform well in other systems like optical domains. The OOK used in this proposed system because of its simplicity and easy design. In this work, a wavelet-ANN based receiver is proposed. In ANN, a back-propagation concept was used for minimizing the error in system.

The CWT used in the system acts as a pre-processing feature for neural network. The main issues in the system are ISI and light interference. For this, high value filters are used for handling the noise in system. In neural network, it takes 100 neurons in first layer and provided 1 in output layer. These neurons are trained with number of samples before classification occurs. In this, signal is defined as discrete samples with interval 1ns. The CWT used in the system has replaced the use of filters and sampler.

IV. CONCLUSION

The unique characteristics of the optical wireless channel exhibited challenges and opportunities. Constraints and interferences presented to the channel need to be taken into account when designing communication systems. In order to improve channel throughput, the first step was to set up the appropriate channel model. This work investigates the use of artificial intelligence and wavelet analysis as the main elements of indoor optical wireless communication receiver. The work uses the MATLAB tool for providing effects of Inter-symbol Interference and light interference on this receiver. This included fully understanding the mathematical model of the channel, noise sources and error performance under each or combined interferences. The performance of this system will be analyzed based on BER value.

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