Optical Data Transfer in Underwater System using Lifi

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***Abstract*— We present wireless optical communication system for data transfer in the underwater networks. We use the optical channel to facilitate the communication link in free space and under water. This work bypasses the limitations involved in the use of electromagnetic waves and acoustics for free space and underwater communication. The system shows that optical communication using light can be a good solution for underwater data transmission applications that requires high data rate at the moderate distances. We have designed, implemented and tested our system in real time and provide the evaluations results.**

***Index Terms*—Wireless Optical Communication, Underwater Networks, Experimental Evaluation, Hyperterminal**

I INTRODUCTION

High-speed underwater optical communication has now become an enabling technology that has many prospective employments in a range of environments from the deep sea to coastal waters. This development effort has enhanced infrastructure for scientific research and commercial use by providing technology to efficiently communicate between surface vessels, underwater vehicles and sea floor infrastructure [1].

The restrictions involved in acoustics such as frequency attenuation disburse its bandwidth. Therefore acoustic tactic cannot attain higher data rates. Optics has been proposed as the best alternative in an attempt to overcome the restrictions involved in acoustics [2]. The need for wireless optical systems is accelerated by several factors. Primarily, more and more bandwidth is required by the end user; which means that more data access must be provided. Secondly, cost is an important factor for the broadband communication industries. Optical communication is a better solution for wireless communication at short distances, as, the same hardware can transfer data in air and underwater with higher data rates and lower cost [3].

We here introduce an underwater optical communication system that is able to communicate wirelessly at a transmission rate of 9600 bps over the range of 4 meters using LED’s as the photon source. The system consists of a transmitter that directs light beam in the direction of the receiver, thereby, converting the electrical data signal into optical signal. Transmitter accepts data over a serial interface which is encoded according to the specification and light pulses generated through LED’s. Receiver detects the optical signal and transforms it into electrical signal. It consist of a photo diode which is sensitive for wavelength of 460nm upto 520nm.

II INTRODUCTION TO LIFI

Light Fidelity (**Li-Fi**) is a bidirectional, high-speed and fully networked wireless communication technology similar to Wi-Fi. The term was coined by Harald Haas and is a form of visible light communication and a subset of optical wireless communications (OWC) and could be a complement to RF communication (Wi-Fi or cellular networks), or even a replacement in contexts of data broadcasting.

It is wire and UV visible-light communication or infrared part of optical wireless communications technology, which carries much more information and has been proposed as a solution to the RF-bandwidth limitations.

A. Applications of LIFI

I.*Security*

In contrast to radio frequency waves used by Wi-Fi, lights cannot penetrate through walls and doors. As long as transparent materials like windows are covered, access to a Li-Fi channel is limited to devices inside the room.[43]

II. *Underwater Application*

Most remotely underwater operated vehicles (ROVs) use cables to transmit command, but the length of cables then limits the area ROVs can detect. However, as light wave could travel through water, Li-Fi could be implemented on vehicles to receive and send back signals.

While it is theoretically possible for Li-Fi to be used in underwater applications, its utility is limited by the distance light can penetrate water. Significant amounts of light do not penetrate further than 200 meters. Past 1000 meters, no light penetrates.

III. *Hospital*

Many treatments now involve multiple individuals, LiFi system could be a better system to transmit communication about the information of patients.[46] Besides providing a higher speed, light waves also have little effect on medical instruments and human bodies.

IV. *Vehicles*

Vehicles could communicate with one another via front and back lights to increase road safety. Also street lamps and traffic signals could also provide information about current road situations.[

III. Related Work

Different approaches for underwater wireless optical communication have been studied since there has been a rising need for automating the underwater research applications.

The proposed work is motivated by the idea of many works such as [4] in which the author proposed an underwater optical system using LEDs that is able to communicate at 10 Mbps over the range of 20m for use on AUVs. The author compares the results for two different wavelengths of the ultra violet region of 660nm and 450nm.

The author shows that a change of offset distance by a few centimetre causes the data rate to drop from 8.2 Mbps to 0 Mbps as a function of turbidity level, viewing angle and separation distance. The channel impulse response was assessed under the different system parameters such as beam wavelength, link distance, receiver's field of view, aperture size and water type. They showed that the channel time dispersion can effect data transmission for longer distances. Moreover they determine the BER as a function of distance and show that a targeted BER of 10^{-6} is achievable at a transmission distance of 48m and 19m in clear and coastal waters, respectively.

The authors show that at transmission speeds of 1 Gbps and at distance of 2m with 32dB of extinction, as a function of absorption and scattering coefficients. The results of frequency response of the propagation medium calculated from Monte Carlo data showed that there should be high bandwidth for range of water conditions that can support data rates greater than 1 Gbps over moderate distances.

The difference of our work that transmission speeds of 9600 bps and a distance of 4m inside a fish tank are considered. The distance may increase while increasing the size of the tank. Moreover, we determine optimal wavelength for underwater communication that experiences least attenuation. However, we do not take into account different water types and transmitter receiver parameters. We will show in the next sections that with increasing distances the received signal strength decreases. We will also define optimal transmission rates at moderate distances.

IV. SYSTEM DESIGN

In this section, we present an overview of our system design. Key components of the system are: transmitter, receiver and a computer. The computer sends data to the transmitter which transforms electrical signal into optical signal. The data modulates on the optical signal and passes through the underwater channel and is detected by the receiver. The receiver converts the detected optical signal into a electrical signal; which is then received by the receiving computer. In the following sections, we provide details of the optical transmitter and receiver.

A. Optical Transmitter

While designing an optical communication system, the main part is to select the type of photon source, since the rest of the circuit components will condition the photon source. So as to select the most appropriate photon source, it is necessary to compare the available sources which are LEDs and laser diodes, in terms of cost, simplicity, efficiency and restraints on the system as well as the use of the system in both free space and underwater. Both LEDs and laser diodes have merits and demerits, although laser diodes have higher optical output, minimal divergence and coherent light, they are not optimal for underwater communication. Since the system has to be deployed in a confined space and limited power AUV, the system needs to be compact and power efficient. Consequently, it has to work underwater without exact alignment of the transceivers due to floating AUV. The system has to be power efficient, small sized, less complex which can transmit at longer distances that's why LEDs are a viable choice due to their less cost, size, power and longer lifetime.

To construct an optical link it is important to understand the loss of optical energy. Absorption and scattering effects the light propagation in water. Both of these factors are wavelength dependent and results from attenuation and broadening of light by water molecules and marine hydrosols (mineral and organic matter).

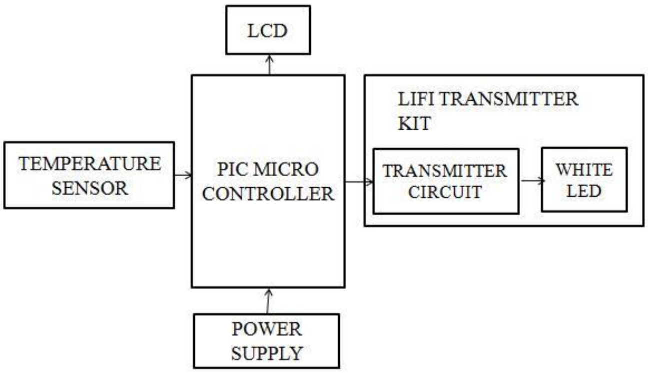


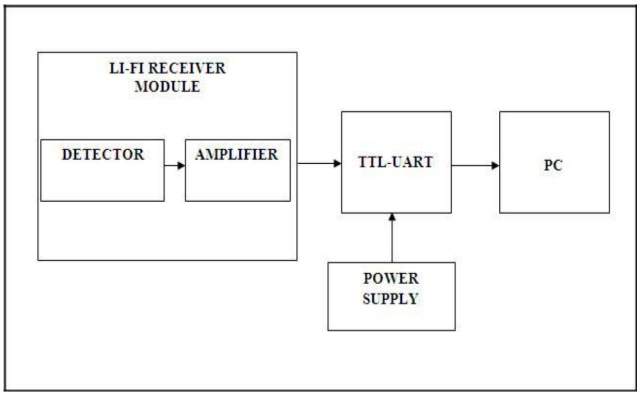
Fig1: Block Diagram of transmitter

B. Optical Receiver

The optical receiver comprises of photon detector, which transform optical energy into the electrical current.

Photo diodes were used as the photon detector because of their faster speed, small size and excellent ambient noise performance. As photo-diodes are current controlled devices, the current needs to be changed into voltage, which is then buffered and squared by comparator and finally made compatible with RS232 voltage levels (see Figure 4). As discussed earlier, photo-diode is a device that operates in reverse bias, and the reverse current increases with the increasing light intensity. Most electrical devices work based on changes in voltage levels as opposed to changes in current levels. Therefore, the current signal coming from the photo-diode must be first transformed into a certain voltage level. One of the basic ways of achieving this is Ohm’s law.

The device is used as variable voltage regulator in the circuit to provide 3.7V for laser source. This part of the circuit serves as a redundant power source for the rest of the circuit which requires less than 5V. The output of the device can be fed to the laser source in case the other LED source does not work. In this way, the circuit can be used for both LED and laser sources and consequently the system can operate both underwater and in free space.



V. IMPLEMENTATION

We made a fish tank. The LED source system and transceiver kit were placed outside the tank. Temperature sensor is fixed to detect the temperature.

The other transceiver which is used as receiver was placed at the other end of the tank. There is PC connected at the both end. TTL-UART is used for serial communication. For power supply transformer is fixed which will convert the 230V to 12V.

Each PC has to open hyper terrminal for the data transmission. There is a switch connected to on & off the temperature sensor. If it is off the temperature sensor value will display, If it is on the data which is typed in the transmitter will be displayed at the receiver. There is Light used which is called LIFI kit.

VI. EVALUATION RESULTS

For testing the system, a signal was sent between the transceivers with varying distances and different speed by changing the baud rate. To better imitate deep ocean conditions, performance tests were performed in the dark. A Embedded code was used to transmit data and assign different transmission speeds. Also, the code was used to push data signal via serial port to the transmitter and on the reception end to receive the data signal from the serial port. Data was successfully sent and received at both ends. Errors were encountered when the data rate was increased especially at greater than 1 Mbps. Optimal transmission results were received at 9600 bps till 1 Mbps at distances from 4m till 6m respectively as a function of the increasing distance, measured at regular intervals after every 2 meters. Keeping the data rate constant, dB loses after every 2 meters were calculated for 9.6 Kbps, 1 Mbps and 2 Mbps transmission rate.

VII. FUTURE SCOPE

Realizing these results, further work will be needed to evaluate the underwater optical systems under real-time parameters. Also, evaluation is needed on a range of water conditions while minimizing the errors induced as a result of the underwater losses. In future the transmission can be done for more distance and also the components also in underwater for more efficiency. The delay may be reduced in the future.

VIII. ACKNOWLEDGEMENT

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IX. REFERENCES

[1] M. A. Chancey, "Short range underwater optical communication links," Master's thesis, North Carolina State University

[2] "Underwater Optical Wireless Communication," Hemani Kaushal, (member of IEEE), Georges Kaddoum (member of IEEE) dept of Electronics Communication and Engineering, NorthCap university, Gurgaon India.

[3] N. Farr, A. Bowen, J. Ware, C. Pontbriand, and M. Tivey, "An integrated, underwater optical/acoustic communications system," in *OCEANS IEEE-Sydney*.

[4] S. Bloom, E. Korevaar, J. Schuster, and H. Willebrand, "Understanding the performance of free-space optics [invited]," *Journal of optical Networking.*