An Efficient Wireless Data Transfer Model For Underwater Communication Using Li-Fi Technology

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Abstract- Nowadays, there is extensive ongoing research activity relating to underwater communications and underwater sensor networks. On one hand, the main research lines are based on increasing the distance and bandwidth, and, on the other hand, the attempt to reduce the energy consumption of underwater devices, with the aim of increasing the network lifetime. This underwater communication system using Li-Fi technology which provides protection against ship collisions on the sea. Li-Fi(Light Fidelity) is an emerging technology which uses the visible light spectrum for communication. This project focuses on the safety on sea in which the headlights, which consists of LEDs acting as transmitter, communicate with photo sensors acting as receiver. White LEDs used in the head and tail lights can effectively be used for short range communication with the photo detectors. The application is cost effective as LEDs are cheap and simple algorithms are proposed for signal generation and transmission.

Keywords-Li-Fi, Underwater communication, LED

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 userwhich 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 consists of a photo diode which is sensitive for wavelength of 460nm upto 520nm. 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.

II LITERATURE SURVEY

There have been some studies done in the past regarding the underwater communication.

Different error codes are applied to the modelled underwater channel [1]. The encoding of the data is carried out prior to the modulation scheme. An (63, 53) RS code [2,3] is applied and author obtained a 10-3 as error rate in air medium. Authors also showed that the considerable coding gain was obtained using Trellis Coded Modulation [4] scheme in the underwater communication. Spectral analysis of signals is carried out in[5]. In underwater communication [6] optimal frequency plays a vigorous role in obtained better error rate. In [7], authors obtained an experimental formula for the optimal frequency for a particular distance.

With this predicted frequency, simulation is carried out for the error coding techniques like Turbo codes [8, 9], convolution code. The results showed that the convolution code with least hamming distance gives least error. The variation of the guard interval (GI) in the orthogonal frequency division multiplexing is studied in detail [10]. A sample image is first converted into binary format and then it is transmitted to the modelled channel. The authors proved that error free communication was obtained if the GI interval maintained is 25% of the encoded data. The purpose of this technique is to eliminate the Inter-Symbol-Interference [11, 12] in the time varying channel like underwater channel.

The study of decision feedback and linear equalizer in the underwater channel is studied in [13]. The authors designed the channel at two different ranges, one at 100 meters and another one at 1000 meters. An optimal step size obtained for the LMS equalizer is 0.05 to 1. For RLS algorithm [14, 15] it lies between 0.02 and 1. The simulation result concluded that the Error Rate of 10-4 is achieved with the signal strength of 24 dB using RLS algorithm. The data communication using Dolphin clicks [16] are carried out by the authors. The proposed algorithm is evaluated by comparing its performance with the well-known standard techniques OFDM and the equalizer. The result evident that the dolphin click [17, 18] produces an error rate which is one fifth of the error rate generated by the former techniques.

The polynomial in the convolution code was modified and its performance was evaluated in the underwater communication for different code-rate[19]. As the code rate increases the error rate decreases gradually and the time consuming algorithm of the LDPC code can be simplified by splitting the longer code rate of the convolution code into series of smaller code rate. This ensured the same error rate produced by the LDPC code[20, 21] in the underwater communication. Statistical analysis[22] of signals and classification of non-stationary signals[23] are analysed using signal processing toolbox. In[24], author effectively communicated in the sea floor between the underwater vehicles using optical signals. This enhanced the researcher to carry out their work in the field of the underwater communication. A high speed optical communication at speed of 10 Mbps was demonstrated in [25] over a short range of 20 meters.

III. HARDWARE IMPLEMENTATION

The main goal of this paper is to simplify things and put in real-time underwater wireless communication. A simple, low-cost automated system that makes wireless communication in underwater is possible. Acoustic modems may not be the ideal choice due to limited bandwidth, high propagation delay, 3D topology; media access control, routing, resource utilization, and power constraints. The block diagram of the proposed transmitter block has shown in figure 1 and the receiver block diagram shown in figure 2. Li-Fi's high speed, highly secure data transfer, and energy efficiency. Communications made underwater can be observed and analysed. Additionally, we may develop a straightforward, inexpensive prototype for use in real-world, commercial applications.

a. customized arduino uno microcontroller

An open-source initiative called Arduino developed microcontroller-based building blocks for interactive items and digital gadgets that can perceive and control real-world objects. The project is based on designs for microcontroller boards made by a number of suppliers utilising different microcontrollers. A variety of expansion boards (also known as shields) and other circuits can be interfaced with these systems' sets of digital and analogue input/output (I/O) pins. For loading software from personal computers, the boards have serial communication interfaces, some of which include Universal Serial Bus (USB). The Arduino project offers an integrated development environment (IDE) based on the programming language processing, which additionally supports the languages C and C++, for programming the microcontrollers. A microcontroller board called Arduino Uno is based on the ATmega328P. It has a 16 MHz quartz crystal, 6 analogue inputs, 14 digital input/output pins (of which 6 can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything required to support the microcontroller; all youneed to do is use a USB cable to connect it to a computer or an AC-to-DC adapter to power it. Many features in the Arduino Uno allow it to communicate with a computer, other Arduino boards, or other microcontrollers.

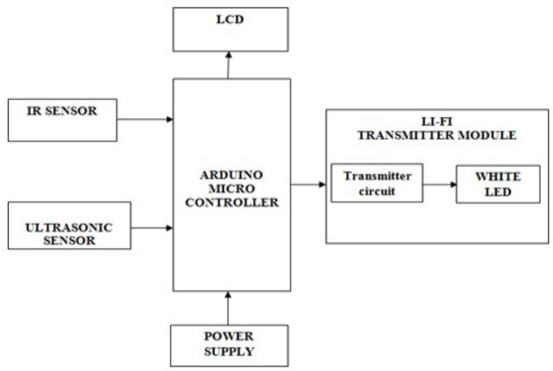

Fig. 1. Block diagram of the transmitter setup

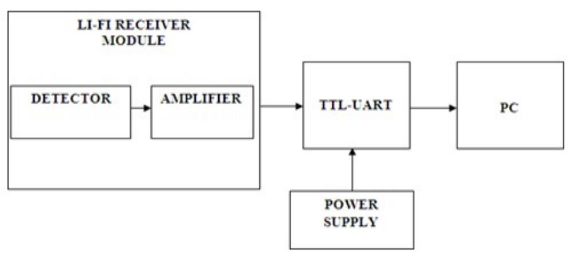

Fig. 2. Block diagram of the receiver setup

b. power supply

The crucial section is the power supply one. It must provide regulated power with a steady output in order for the project to function properly. For this, a 0-12V/1mA transformer is employed. This transformer's primary is connected to the main supply through an on/off switch and fuse to prevent overload and short circuits. To change 12V AC voltage to 12V DC voltage, the secondary is linked to the diodes. Capacitors provide filtration, while IC 7805 further regulates the voltage to +5 volts. Capacitors filter the signal, which is then further regulated to +12 volts by IC 7812.

c.LCD

An industry-standard liquid crystal display (LCD) display device for interacting with embedded electronics is the HD44780 Character LCD. These screens are available in standard configurations including 8x1, 16x2, and 20x4, among others. The greatest possible arrangement of this kind is 40x4 characters, but they are uncommon and are actually two distinct 20x4 screens that have been flawlessly connected. These displays are frequently used in copier, fax, laser printer, industrial test, networking, router, storage, and other devices. These screens are not comparable to those found in cell phones, portable televisions, etc. They can only use text and a maximum of 8 configurable characters. Backlights might be electroluminescent, fluorescent, or LED. Standard 14-pin interfaces are used by character LCDs. The screen will have 16 pins if the backlight is present.

d. IR sensor

Infrared light is produced by IR LED. The surface in front of LEDis illuminated by this radiation. The amount of light reflected varies depending on the surface's reflectivity. The reverse biased IR sensor is made to incidentally receive this reflected light. The quantity of electron-hole pairs produced is influenced by the strength of the incident IR radiation. Therefore, as the intensity of the incident ray changes, the voltage across the resistor also changes.An electrical gadget that produces infrared light to sense certain features of its environment is called a sensor. An IR sensor can monitor an object's heat while also spotting movement. Typically, all items emit some type of thermal radiation in the infrared range. Although these radiations are invisible to the human eye, an infrared sensor can pick them up. An IR LED (Light Emitting Diode) serves as the emitter, and an IR photodiode, which is sensitive to IR light of the same wavelength as that emitted by the IR LED, serves as the detector. When IR light strikes the photodiode, the output voltages and resistances vary in direct proportion to the intensity of the IR light received.

e. ultrasonic sensor

The time it takes for an ultrasonic pulse to travel from an ultrasonic sensor to an item and back to the transducer is measured. The transducer emits sound waves, which are reflected by an object and returned to the transducer. The ultrasonic sensor will switch to receiving mode after it has finished emitting the sound waves. The length of time between sending and receiving is inversely proportional to the separation between the item and the sensor. After an ultrasonic wave was launched, an ultrasonic transmitter began to produce waves in that direction. When it came into obstructions on the route, the ultrasonic spread in the air would immediately turn around and go back. When the ultrasonic receiver finally receives the reflected wave, time would end. Calculated is the sensor's separation from the intended item. It provides superior non-contact range detection in a user-friendly design with high accuracy and reliable readings. Neither sunshine nor dark objects have an impact on its operation. The sensor receives a 5 VDC supply voltage. The controller is attached to the sensor's two trig and echo pins, which are used as digital input.

f. LI-FI

Similar to Wi-Fi, Light Fidelity (Li-Fi) is a bidirectional, fast, and completely networked wireless communication technology. Visible light communication is a subset of optical wireless communications (OWC) and may be used in place of RF communication (such as that provided by Wi-Fi or cellular networks) in certain data broadcasting scenarios. It is part of optical wireless communications technology, which transports far more information, and has been suggested as a solution to the RF-bandwidth limits. It uses wire and UV visible light communication or infrared and near-ultraviolet instead of radio-frequency spectrum. By rapidly turning the current to the LED on and off, too quickly for the human eye to see, visible light communications (VLC) operates. Li-Fi LED could be dimmed to below human visibility while still emitting enough light to transfer data, even though they would need to be kept on to transmit data. Compared to Wi-Fi, the light waves' range is much less but more secured against hacking because they cannot pass through barriers. Li-Fi does not require a direct line of sight to broadcast a signal; light reflected off of walls can reach 70 Mbit/s.

g. UART

A computer hardware device known as a universal asynchronous receiver-transmitter allows for configurability of the data format and transmission rates for asynchronous serial connection. In order to ensure that the communication channel can handle exact timing, it delivers data bits one by one, starting with the least significant and working up to the most significant. An independent driver circuit manages the electrical signalling levels from the UART. RS-232, a 12-volt system, and RS-485, a 5-volt system, are two popular signal levels. Current loops were employed in early teletypewriters.

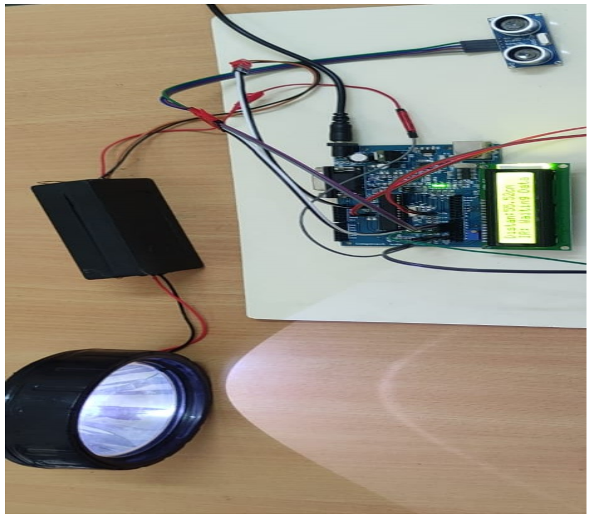

Fig. 3. Hardware implementation of the proposed transmitter block

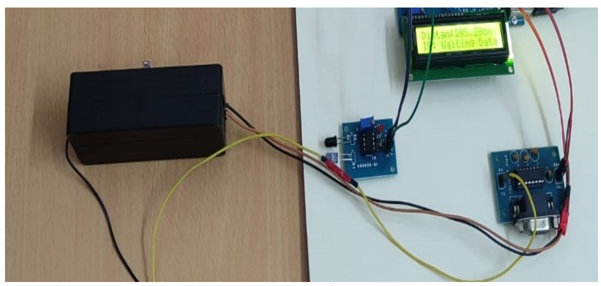

Fig. 4. Hardware implementation of the proposed receiver block

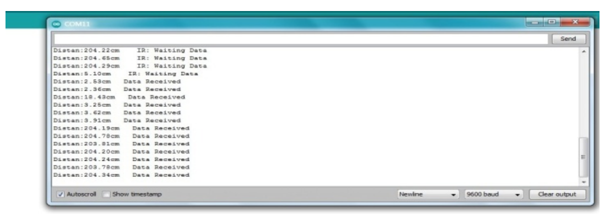

Fig. 5. Communicated results shown in PC

In order to test the system, a signal was delivered between the transceivers at various speeds and distances by altering the baud rate. Performance tests were run in the dark to more accurately simulate deep ocean conditions. Different transmission speeds were assigned and data was transmitted using an embedded code. Additionally, the code was used to push data signals via the serial port to the transmitter and to receive data signals from the serial port on the receiving end. At both ends, data was successfully transferred and received. When the data rate was raised, particularly above 1 Mbps, errors occurred. With distances ranging from 4 metres to 6 meters, optimal transmission results were obtained at 9600 bps and 1 Mbps, respectively.

IV CONCLUSION

The general design of a system that is helpful for speedier, one-to-one underwater communication. The communication issue is resolved, and secure data communication is provided. For ship security purposes, our technology works well. Long-distance communication would be improved if the Navy adopted this technology. Therefore, using our method for underwater communication would be effective. Li-Fi has a greater communication range, doesn't disperse in water, uses less power, requires less packaging, and can transmit data at a faster rate. With all these benefits, we conclude that Li-Fi is a more advanced technology than acoustic means of communication for use in underwater communication.

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