Underwater Li-Fi Communication for Monitoring the Divers Health

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Abstract. Diving has become a common way of performing research in the underwater living world. One of the major problems with diving is the health issues faced by the divers during diving and there comes the need for monitoring diver's health. This paper mainly focuses on the health monitoring systems for divers by transferring the data using Li-Fi (Light Fidelity). This system senses different health specifications like heartbeat, body temperature and lung expansion. The monitored health specifications are recorded as a database in a memory chip for further analysis. To reduce the power consumption, the system transfers the data to the nearby divers and ship only during the abnormal health issue. The proposed system can be used up to 120 meters sea depth and the data can be transferred up to 5 receivers at a time.

Keywords: Underwater · Li-Fi · Li-Fi communication · Health monitoring of divers

1 Introduction

Visible Light Communication is the other name for Li-Fi. Li-Fi can transmit the data using a high illumination LED that varies the intensity faster than the human eye [1]. The distance traveled by the Li-Fi is 10-30 m underwater to transfer the data and there will not be much interference produced from Li-Fi. The data encoded in binary form is sent to the light transmitting systems by high illumination LED. The information is transmitted by switching the LED ON and OFF to produce 0's and 1's.

In previous existing methods, the data is transmitted via acoustic communication, ultrasonic communication, wired communication, voice communication, RSTC hand signals, and torch/Flash signals. These existing communication systems faced difficulties in propagation under sea water. The optical method proposed in [2] for communicating between two autonomous underwater vehicles. The system transfers the data with very less power. The range differs due to environmental conditions. It differs according to clear and muskier water. Corentin et al. [3] developed an algorithm for detecting the breath of the scuba diver. They analyze the signal by using the algorithm if there is no breathing from scuba divers it will produce the alarm to the nearby ship. the delay noted from transferring the data is 5.2 s. The memory used to store the data in Random Access Memory is 800 bytes. The design considerations of underwater optical communication to detect with different parameters is said in [4] and the major

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drawback is the attenuation loss due to the scattering of light. To obtain high bandwidth optical communication which is simulated using Monte Carlo in [5] where the data rate is greater than 1gigabits/second the data transfer does not require any physical contact.

Vijaya [6] proposed underwater point to point communication that causes the misalignment in the optical link due to absorption and scattering, so the transmitter and receiver are misaligned. The alignment of the transmitter and receiver is achieved by increasing the divergence of the transmitted beam. Thomas [7] used two orthogonal laser beams and two receiving optical link to receive the data in the sea. By using laser communication system technique, it reduces the transmission error problems and it will also limit the scattering levels. To achieve high data rate, it requires sufficient intrinsic bandwidth. Chiarella [8] planned to develop communication by diver gestures, known as CADDIAN language. The gestures are signs, symbols, alphabets, semantics. In muskier water, it was difficult to communicate. Tran [9] proposed a transceiver design of acoustic space frequency block code OFDM to increase the data throughput for vertical link communication in underwater. It also increases the data throughput up to 7.5 kbps. It also produces noise, multipath, and sampling rate error. Hachioji-shi [10] proposed a theory for detecting a stray recreational diver underwater. This theory was simulated using network simulator and the data rate is evaluated. The implementation at underwater propagation model is done at 50 kHz.

2 Proposed Method

The proposed method consists of transmitting and receiving section. The transmitting section detects the abnormalities faced by the diver and the data is transferred by using the medium called light fidelity. In receiving section the light signal is converted in the form of electrical signal and the data is produced in the form of audio.

2.1 Transmitter Section

The transmitter section consists of PIC microcontroller, IR sensor, Li-Fi, heartbeat sensor, temperature sensor, emergency switch, a transmitting module, power supply and LCD module shown in Fig. 1. The step-down transformer is used for generating the power to the device. The heartbeat sensor is used for sensing the pumping of the heart or it can also be measured in the finger artery by presenting the variations in the blood volume. The infrared LED transmitting an IR signal into the finger and the reflected infrared light from the blood cells are transmitted with a pulse train into a photodiode. For sensing the temperature LM35 sensor is used which is used for converting the body temperature into an electrical signal. LM35 is small in size and produces very high accuracy with very less power. The microcontroller is used for interfacing all the devices and it also consumes very less power. The memory stored in Random Access Memory is 368 bytes. The microcontroller is connected to the LCD display andthe infrared sensor is used for detecting the obstacles during the transmission of data. The light fidelity module consists of a transmission section that

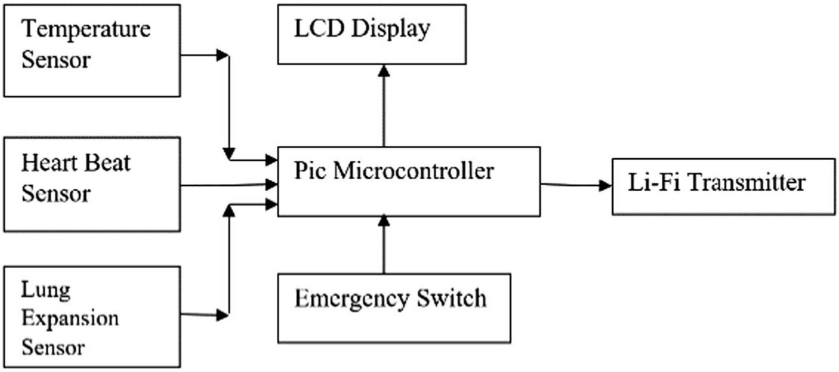

Fig. 1. Block diagram of transmitting section

produces a white LED for transmitting and receiving the information. LED's are used for its low value, little in size and consumes less power. The data is produced through the Li-Fi to the receiver section.

2.2 Receiver Section

The receiver section consists of Li-Fi receiver, LCD display, and the audio player. The data transmitted from the Li-Fi is 1 giga bits per second. The data received from the Li-Fi transmitter will be in the form of a light signal. The light is passed into the photodiode receiver. The photodiode is used for converting the light signal into an electrical signal. The electrical signal is given into a double stage amplifier which is used for amplifying the detected electrical signal. The electrical signal is converted into binary information. Binary information is converted into the original message and the data is produced at the output in the form of audio signal/message (Fig. 2).

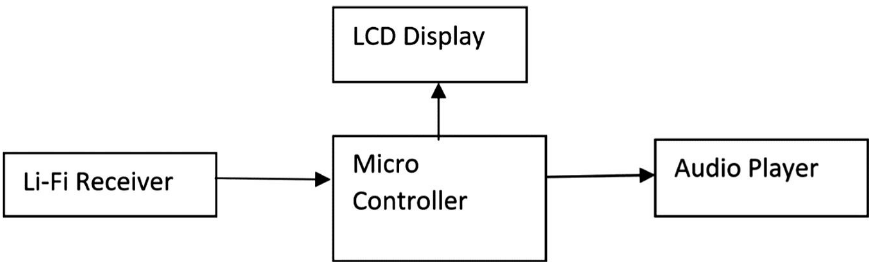

Fig. 2. Block diagram of receiving section

3 Experimental Result

The output will be produced if there are any emergency health issues faced by divers. There is also an emergency switch if the diver faces any issues that person can press the emergency switch. In the proposed system (Figs. 3 and 4), three different sensors like heartbeat sensor, temperature sensor, and lung expansion sensor are used. If there were any abnormalities faced by the diver, the sensors will detect and give the data via Li-Fi as a light signal.

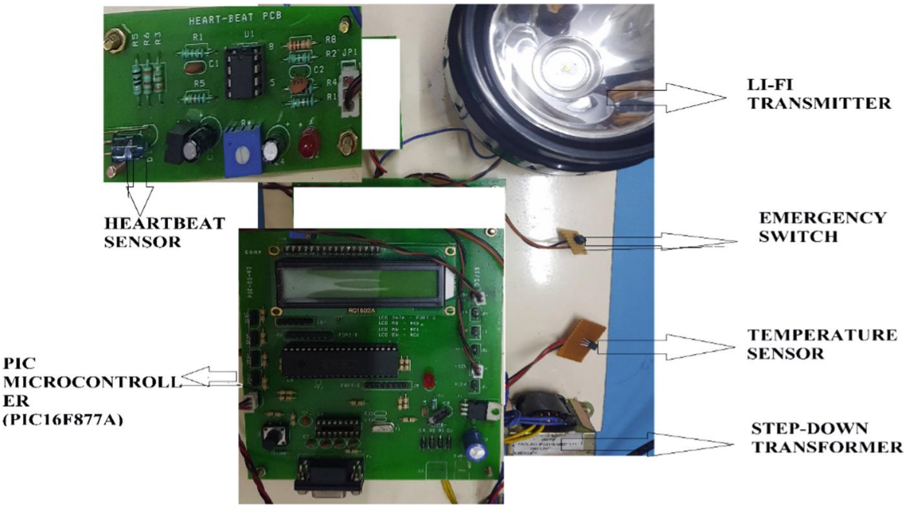

Fig. 3. Li-Fi communication transmitter

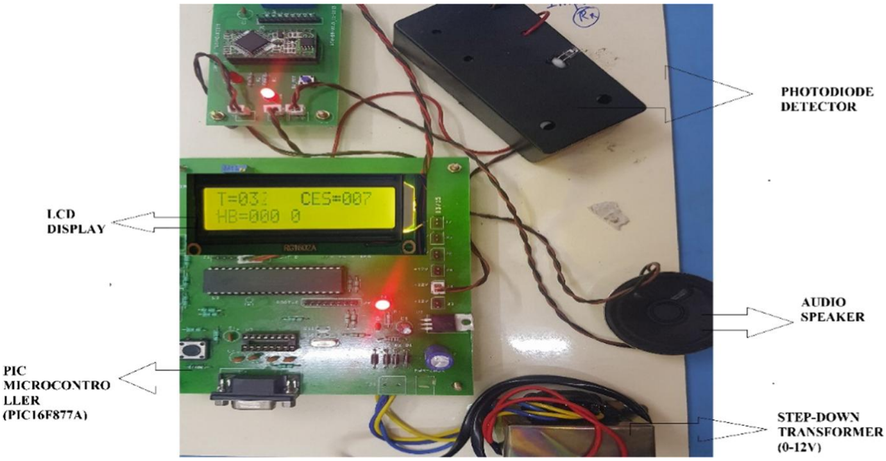

Fig. 4. Li-Fi communication receiver

The received light signal by the nearby diver's receiver is passed into the photo-diode which will convert the light signal into an electrical signal and produces the output in the form of an audio signal. The received audio signal spectrum is shown in Fig. 5. The experimental output is seen in the form of the audio spectrum. The data observed from the audio is converted into an audio spectrum. If there are any abnormalities observed from the diver is produced in the output. the audio spectrum shown below are emergency alert audio spectrum shown below in Fig. 5, heart rate audio spectrum shown below in Fig. 6 (the sample results are taken by author itself (PARTICIPENT NAME: DURGA R)). the temperature sensed audio spectrum shown in Fig. 7. If there was any abnormality detected from the diver is passed to the nearby diver or ship.

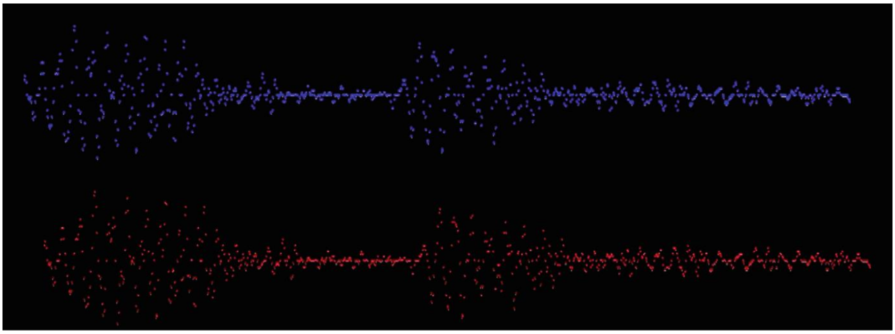

Fig. 5. Audio spectrum for emergency switch alert

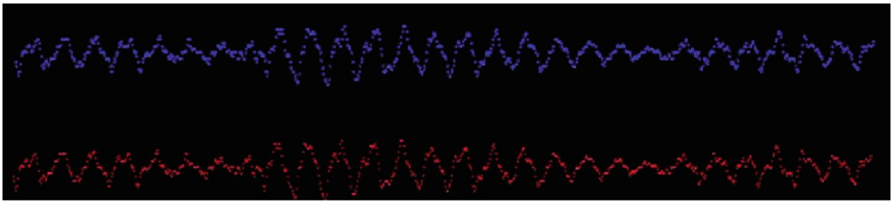

Fig. 6. Audio spectrum for heart beat if there is any abnormality

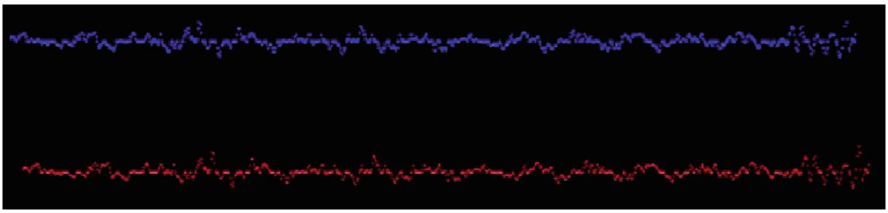

Fig. 7. Audio spectrum for temperature if there is any abnormality

4 Conclusion

The data is produced only at the time of emergency so, it consumes very less power. The device is very cost effective. It transmits the data at a speed of 2 Giga Bits Per Second (Gbps) which is faster than the existing systems. The data can be transmitted between 5 divers and a ship. The proposed system can be majorly used for rescue operations under the sea. It can also be used for ship to ship communication. So, this system may replace the existing underwater techniques.

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