Design and Implementation of Under Water Optical Wireless Communication

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Abstract

This paper tells us about how the underwater optical wireless communication by using infrared light technology (IR) for data transmission in underwater. Like the present underwater acoustic communication technologies are not that much up to the mark for the future underwater wireless communication due to its very low data rates and the delay in transmission of the messages. This system consists of IR's transmitters and receivers which are waterproof in nature and also gives good efficient results in data communication between transmitters and receivers. The system testing is done in different environment cases such as water tanks, swimming pools, etc. The results shows us that the IR light can penetrate through water better than other technologies and it shows better comparison results in different testing cases in the environment. This system records better results than the present acoustic water data transmission rates which are present in nowadays underwater wireless technology. The choice of IR is due to its cost-effectiveness and easily available in the market and it passes through water very easily and giving us better results. The underwater optical wireless communication system has many applications in different areas such as underwater monitoring, military applications, and communication with submarines and also with underwater vehicles.

Keywords: Underwater optical wireless communication, infrared light, data rates, delay, acoustic communication, underwater monitoring.

1. Introduction

This paper gives us an overview of the Underwater Optical Wireless Communication (UWOC) by using infrared technology like it is the best solution for the present underwater and upcoming problems like, delay in passing the messages and wireless communication for better transmission [1]. The IR's lights are used as both as the transmitters and receivers and having waterproof in nature so there is no tension of the hardware components getting spoiled due to the in presence of underwater [2][3]. While the blue-green light gets lesser absorption in the underwater so because of this reason the IR technology was selected for easy transmission and cost-effectiveness and easily available in the market. Testing the system if in different and various underwater environments for getting the better results and good analysis on the system that how much it has stability for the transmission or wireless communication in underwater. So, this system consisting of the IR technology has good capability and good transmission of data in underwater in different scenarios of the present controlled environment which has good outcome of the system in underwater [3] .

Acoustic communication limits high-speed underwater data transmission. The problem leads to limited real-time data sharing and operational efficiencies within underwater environments, important for scientific investigations, military operations, as well as industrial uses [4]. The difficulty is magnified by the constraints of sound signals in crowded or chaotic underwater environments, where signal degradation and interference are common. However, conventional methods have serious limitations, including poor data rate, high latency, and sensitivity to environmental conditions. Such limitations impede real-time data exchange and effective underwater operations, necessitating the use of a better communication solution. UOWC is a potential alternative, employing IR light for high-speed data transmission. In contrast to acoustic waves, optical signals propagate at much faster speeds and provide much better data rates. The system has been extensively tested in controlled environments and is capable of transmitting data effectively at varying depths and water conditions.

Underwater communication has been researched in multiple areas previously. Paper [5] gave the insight into coding, channel characterization, noise suppression, and acousto-optic hybrid systems. Paper [6] focused on channel understanding, modulation techniques, practical installation, performance testing, and usage. Paper [7] discussed UOWN structures, issues, localization, and full-duplex UOW channel modelling. Paper [8] discussed IR technology integration with Raspberry Pi Pico in underwater communication.

Traditional acoustic communication is challenged by data rate and responsiveness, and underwater operations are constrained by this [9][10]. IR-based UOWC can overcome this and advance data transmission to overcome these limitations and increase underwater communication capabilities [11]. The primary motivation behind this work is to design a high-speed, dependable underwater optical wireless communication (UOWC) system employing IR light.

This objective is broken down into the following specific objectives:

1. Design of under water system with transmitters and receivers by using infrared technology for the excellent transmission of information in underwater.
2. Testing of the system efficiency and performance in different scenarios like swimming pools, water tanks, etc for the better understanding of the outcome of the project and also testing the system in various places and different types of water.
3. Checking the system capability and stability for good transmission and checking the delay in the transmission of information between the transmitter and receiver.

The above objectives which are mentioned are to achieve good and faster data transmission of the different types of the information in underwater communication and it has good advantages and more beneficial applications over the acoustic communication technology.

2. Methodology

2.1 Research Design and Approach

The Under Water Optical Wireless communication enables us the data transmission more easier than the present technologies by using infrared technology which consists of transmitters and receivers and microcontroller Arduino Uno board and developing the system with the above hardware components and implementing it in the different environmental cases like for the better and improvising the results of the system [12][13].

2.2 Data Acquisition and Analysis:

• Temperature and Humidity information: The values of the temperature and the humidity is taken by using the sensor called DHT 11 sensor which gives us the values of the temperature and the humidity in the environment which are the important parameters for to monitoring purposes [14].

• Distance: By using the ultrasonic sensor (HC-SR04) which is in waterproof in nature for the calculating the distance between the transmitter and receiver.

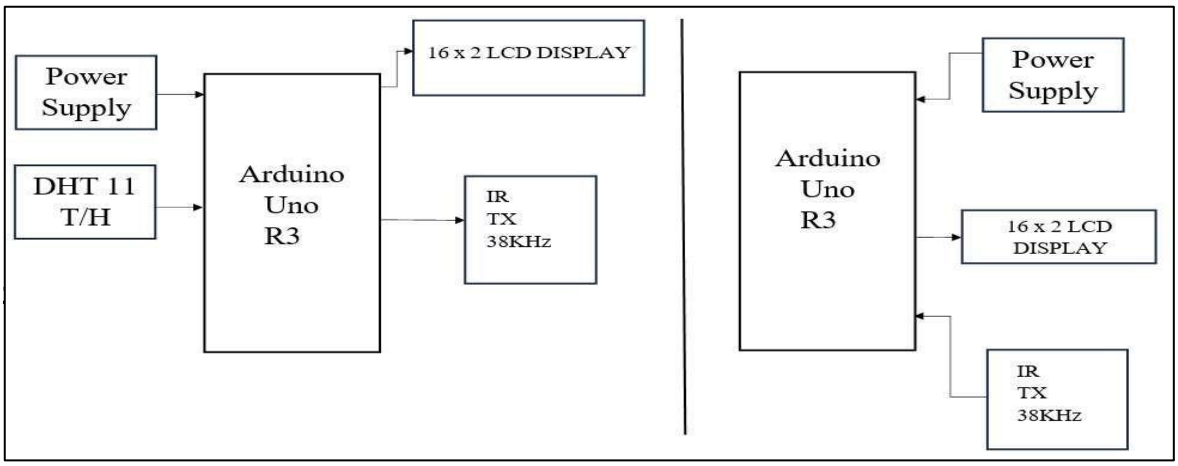

Fig1. Block diagram

- UWOC Fundamentals: Learn about optical wireless communication, IR light transmission in water [15].
- Component Choosing: Utilize IR LEDs, photodiodes, DHT11 (humidity/temperature), HC-SR04 (distance), waterproofing [16][17].
- Experimental Environment: 5W IR LED (850nm), optimized photodiode, 1.5m x 1m x 1m water tank. Signal power through oscilloscope, BER from data purity.
- System Development: Put together IR LEDs, photodiodes, Arduino Uno for transmission/reception, waterproofing [18][19][20].
- System Assembly: Interface Arduino Uno with IR LEDs, photodiodes, and sensor-based sensing [21][22].
- Testing: Perform experiments in controlled water systems (tanks/pools).

2.4 Schematic Diagram

Figure 2 represents the schematic of the proposed model. It provides the detailed pin diagram of the model.

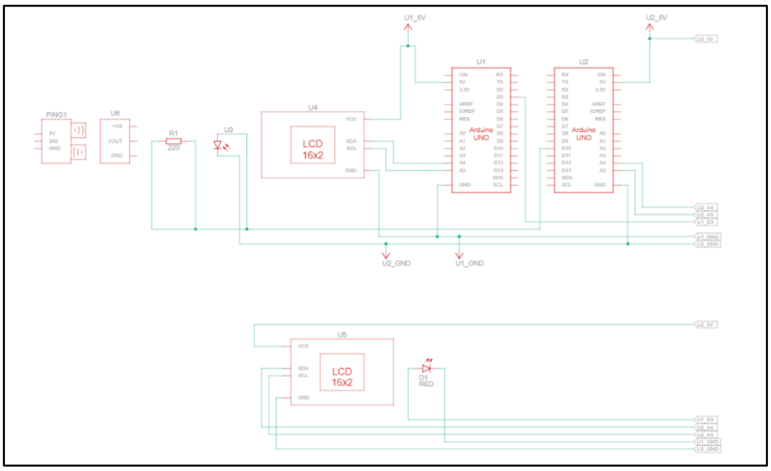

Fig:2 Pin diagram of the model

3. Results & Discussion

The system was able to effectively interconnect all modules for real-time transmission of temperature data with reduced latency and error. The system was able to achieve an efficient communication range of 5 meters in clear water, and a slight reduction occurred in turbid water conditions owing to the augmented attenuation.

Temperature readings, experimented on both LCD and serial monitor, confirmed system reliability and accuracy. The project was experimented in normal, warm, and coldwater conditions utilizing a DHT11 sensor with readings as seen in Table 1. This confirms its use in underwater communication, exploration, and environmental monitoring.

Water Condition	**Temperature (°C)**
Normal	~27
Warm	~38
Cold	~14

Table 1 : Analysis result

The system successfully monitored temperature changes in different water conditions. The readings indicated that the system was able to detect temperature changes precisely. Temperature measurement capability properly in underwater environments is crucial to uses like underwater exploration and environmental monitoring. Figure 3 to 6 represent the real time implementation of the proposed model.

Fig 4: Transmitter part

Fig 3: IR communication across the water medium

Fig 5: Receiver part

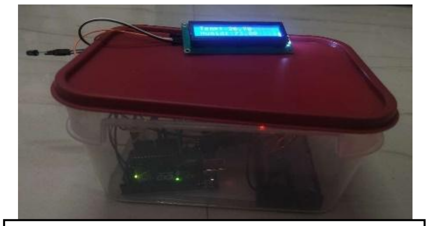

Fig 6: Water proofed

4. Conclusion

The deployment of suggested Underwater Optical Wireless Communication (UOWC) with infrared (IR) sensors for temperature data transmission has shown remarkable improvements [24][25]. The system supported data rates, allowing high-frequency transmission of temperature data. Near real-time transmission of data was ensured, allowing for instant analysis and response. Temperature data were transmitted accurately and reliably. The system worked best in clear water but exhibited decreased range and greater requirement for alignment adjustments in turbid and turbulent conditions. In general, this work was able to effectively demonstrate the potential of UOWC with IR sensors to improve underwater communication capabilities, with important applications in scientific research, military operations, and industrial monitoring.

5. References

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