AQUALINK COMMUNICATION USING ACOUSTIC MODEM

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Introduction

Visible Light Communication based Aqualink system that can be used for wireless communication of messages even through water. The system can prove to be a very cheap alternative to long heavy physical wires that run through seas, rivers and require large costs for laying those wires and their maintenance. Our system makes use of infrared transmitter receiver in order to achieve this system. Our system consists of two microcontroller-based circuits that have IR transmitter-receiver pairs as well as LCD displays for displaying the messages. Each system has a keyboard connected to it in order to type in messages. We use two water barrels in order to demonstrate Aqualink using signals passing through those containers. The system also has an acknowledgement receipt message that is sent back from the receiving circuit to the transmitting circuit on message receipt. This allows for efficient communication between two circuits wirelessly.

Wireless communication has been booming in the recent years. However, not much has been done to accomplish communication in water in a wireless manner which can be useful in many scenarios. Most of the communication modes that are existing as of now are either not reliable or are very expensive. IR rays can pass through water and thus can be used in case of line of sight for communication purpose in this medium. IR Communication using Keyboard uses two units both controlled by ATmega family microcontroller. Both of the units have IR Trans-receivers as communicating agents. Keyboards are needed to be connected on both the ends to enter input to the system. The communication messages get displayed on the LCD connected to the system. The system communicates with confirmation key that is sent back by the receiving unit to the sending unit. In this way wireless communication is implemented with great efficiency within a line-of-sight range of about 3-4 meters under the water with the help of IR Communication using Keyboard project.

Objectives

- To design an algorithm with Transducer/Acoustic Modem to enable wireless transmission system of messages through water, facilitating communication between underwater nodes such as submarines, Autonomous Underwater Vehicles (AUVs), and surface nodes.
- To implement VLC as the communication technology capable of transmitting data through light, making them suitable for wireless communication in aquatic environments.
- To design a system to automate cable handling mechanism to reduce human effort, cutting down on manual cable handling for the use of Military and operational benefits and boosting AUV performance with secure message transmission.
- To sense the water environment like PH, Turbidity, Temperature.
- To design User-friendly features, include keyboard input and Atmega328 microcontroller processing. Its versatility extends its applications beyond the military, making it valuable in research, offshore industries, and environmental monitoring sectors

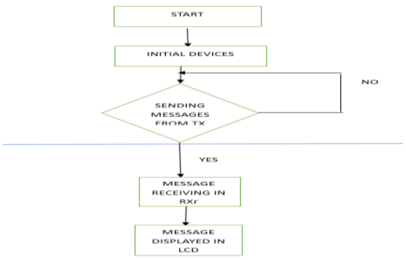
Methodology

The VLC-based Aqualink system's development entails rigorous steps: defining system requirements including range, encoding, and security; selecting components like IR transmitters, Atmega328 microcontrollers, and keyboards; designing circuitry; establishing transmission protocols and acknowledgment mechanisms. Simulated underwater tests validate its efficiency and reliability in message delivery. Optimizations fine-tune the system for enhanced performance. Critical security measures, including encryption, safeguard sensitive transmissions. Overall, this systematic approach aims to create a cost-effective, reliable, and secure.

Materials Required

- Power Supply and Transformer: Steps down AC to 12V, rectifies to 5V DC ensuring a stable power
- LCD Display: Utilizes 16x2 or 20x2 HD44780U standard LCDs, for message display.
- Microcontroller (Atmel ATmega328P): Features a 32K 8-bit AVR architecture,
- IR LED and TSOP Receiver: IR LED transmits infrared rays, while the TSOP receiver decodes remote control signals.
- Pc communication: Acts as an input device, enabling users to enter messages and commands into the system.
- Lifi transmitter: Lifi transmitter part consists of led driver circuit and led with uart extension.
- Lifi receiver: Lifi receiver part consists of photodiode with uart extension, which converts the light pulses received to data and transfers through uart.
- Solar Panel: A solar cell, is an electrical device that converts the energy of light directly

- Temperature sensor: Temperature sensors are vital to a variety of everyday products
- Contact Sensors : Contact temperature sensors measure the temperature of the object to which the sensor is in contact
- PH Meter: A pH meter is essentially a voltmeter with a high input impedance which measures the voltage of an electrode sensitive to the hydrogen ion concentration



Transmitter Side:

1. Arduino Setup: Setup the Arduino board as the main controller for the transmitter side. Connect the pH sensor, turbidity sensor, temperature sensor, and an LCD display to the Arduino.
2. Sensor Calibration: Calibrate the pH sensor, turbidity sensor, and temperature sensor according to the manufacturer's instructions to ensure accurate readings in the underwater environment.
3. Data Acquisition and Processing: Develop code to read sensor data from the pH sensor, turbidity sensor, and temperature sensor.
4. LiFi Transmitter: Integrate a LiFi transmitter module with the Arduino to modulate the sensor data onto light signals. Use a high-intensity LED as the light source for transmitting data.
5. 5.LCD Display: Display real-time sensor readings on the LCD display connected to the Arduino. Update the display with new sensor data periodically.

Receiver side

1. Arduino Setup: Set up another Arduino board as the main controller for the receiver side. Connect an LCD display to the Arduino for displaying received sensor data.
2. LiFi Receiver: Integrate a LiFi receiver module with the Arduino to receive modulated light signals transmitted by the transmitter side. Use a photodiode or phototransistor to detect the modulated light signals underwater.
3. Data Decoding g: Develop code to decode the received light signals and extract the sensor data transmitted by the transmitter side.
4. LCD Display: Display the received sensor data on the LCD display connected to the Arduino. Update the display with new sensor data received from the transmitter side.
5. Secure Communication: Thus, transferred encoded data was received by photodetector which was in the receiver side.

RESULTS

The suggested method is implemented using the LiFi module to transmit and to receive the messages. In our project we can send the messages through two ways: one is through text message with the help of a keyboard and another through switches. There are four switches which collect information from the sensors and display it on the transmitter side and send the same to the receiver end and display the values in the receiver LCD.

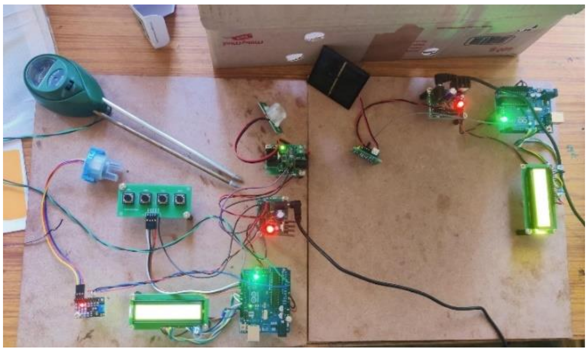


Fig. 1 Final model of Aqualink.

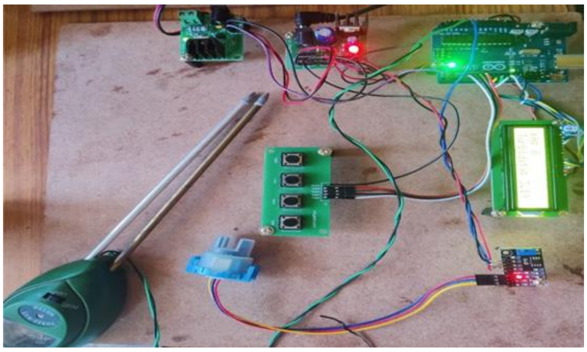


Fig. 2 The transmitter model with switches & keyboard for message sending

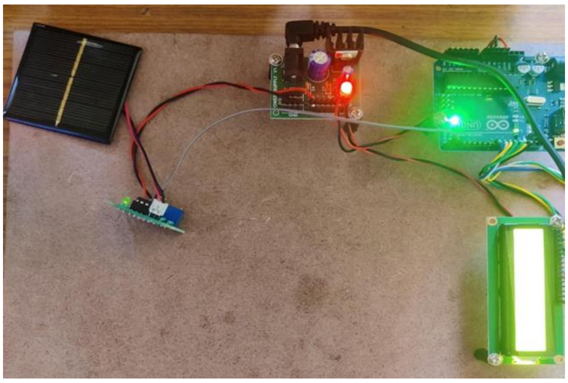


Fig.3 The receiver model with LiFi receiver for message reception.

Fig. 4 pH data collected by switch press

Fig. 5 pH value collected post-switch press

Fig. 6 Picture shows temperature collected from sensor

Fig. 7 The image displays sender's text message and sends it to receiver.

Fig. 8 Text message from sender displayed on receiver.

Conclusion

Proper exploration of the ocean environment for communications requires a clear understanding of the mechanisms affecting the underwater signal, such as the attenuation characteristics originating from the propagation properties of RF, optical, and acoustic transmissions. Modeling underwater signal propagation is very difficult but its understanding plays as key role in determining the effective data processing at the transmitter and at the receiver so that reliable and accurate communications are possible. As expected, each communication technology requires distinct channel modeling, making the task of conceiving a network employing flexible modems much more challenging.

Innovations

1. Adoption of Li-Fi Technology for Underwater Communication
    - Light Fidelity (Li-Fi): AquaLink leverages Li-Fi, a cutting-edge wireless communication technology that uses light to transmit data, adapting it for underwater environments.
    - Optical Wireless Communication (OWC): By using the optical spectrum, AquaLink achieves higher data rates and lower latency, addressing the significant challenges posed by underwater environments such as high attenuation and variable turbidity.
2. High-Speed Data Transmission
    - Modulated Light Signals: AquaLink employs modulated light signals to transmit data at high speeds.
    - Advanced Modulation Techniques: The project incorporates advanced modulation techniques to optimize the transmission and reception of data, ensuring robust communication even in challenging underwater conditions.
3. Reliable and Secure Communication
    - Secure Data Transmission: The system employs encryption and secure communication protocols to protect sensitive information transmitted underwater, addressing security concerns and preventing unauthorized access.

4. Comprehensive Sensor Integration
   - Environmental Monitoring: AquaLink includes the capability to integrate various sensors (e.g., pH, turbidity, temperature) for real-time environmental monitoring. This multi-sensor approach enables comprehensive data collection and monitoring of underwater conditions, providing valuable insights for research and industrial applications.
   - Arduino-Based Control: The use of Arduino microcontrollers for both the transmitter and receiver sides facilitates flexible and customizable integration of sensors, allowing for a wide range of monitoring applications.
5. Efficient and Flexible System Design
   - Cost-Effective Implementation: By utilizing readily available and cost-effective components like Arduino boards and LEDs, AquaLink provides an affordable solution for underwater communication, making advanced technology accessible for a wide range of applications.
6. Innovative Acknowledgment Mechanism
   - Bi-Directional Communication: This bi-directional communication ensures data integrity and reliability, a significant advancement over unidirectional systems.
7. Potential for Wide-Ranging Applications
   - Marine Science and Exploration: AquaLink's high-speed and reliable data transmission capabilities make it ideal for marine scientific research, enabling real-time data collection and transmission from underwater sensors and instruments.

Future Scope

1. Enhanced Communication Range and Depth
   - Extended Range: Current implementations of AquaLink are optimized for moderate distances. Future research could focus on increasing the effective communication range by developing more powerful light sources and sensitive receivers, enabling longer-distance data transmission.
   - Deep-Sea Communication: Enhancing the system to function reliably at greater depths will be crucial for deep-sea exploration and applications. This could involve innovations in pressure-resistant components and advanced signal processing techniques to overcome the challenges posed by deep-water environments.
2. Integration with Advanced Technologies
   - Machine Learning and AI: Incorporating machine learning algorithms can optimize modulation techniques, error correction, and adaptive communication protocols. AI can help in dynamically adjusting parameters based on real-time environmental conditions to maintain optimal communication performance.
3. Development of Comprehensive Underwater Networks
   - Internet of Underwater Things (IoUT): AquaLink can be a foundational technology for developing the IoUT, where interconnected underwater devices communicate seamlessly.

- Mesh Networks: Implementing mesh networking capabilities can allow multiple AquaLink devices to form an interconnected network, improving coverage and reliability by enabling data to hop between multiple nodes.

4. Advanced Sensor Integration
    - Multi-Parameter Monitoring: Future iterations could integrate a broader range of sensors for comprehensive environmental monitoring, including sensors for detecting chemical pollutants, biological organisms, and other critical parameters.
    - Real-Time Data Analytics: Incorporating onboard data analytics capabilities can allow for real-time processing and analysis of sensor data, providing immediate insights and enabling prompt decision-making.
5. Industrial Applications and Collaborations
    - Offshore Energy: Enhancing AquaLink for robust communication in offshore oil and gas exploration and maintenance can improve operational efficiency and safety. Collaboration with industry leaders can drive the adoption and refinement of the technology.
    - Underwater Robotics: AquaLink can be further developed to support advanced underwater robotic operations, enabling better coordination and control of autonomous underwater vehicles (AUVs) used in various applications like marine research, underwater construction, and search and rescue missions.
6. Environmental and Climate Research
    - Long-Term Environmental Monitoring: Deploying AquaLink in long-term monitoring stations can provide continuous data on oceanic conditions, contributing to climate research and the study of marine ecosystems.
    - Disaster Response: Enhancing the system for rapid deployment in disaster-stricken areas (e.g., after oil spills or underwater earthquakes) can provide critical real-time data to support emergency response efforts.