SHALLOW WATER ACOUSTIC NETWORKS SYSTEM

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Abstract - Underwater acoustic communication (UAC) systems are essential for effective data transmission in submerged environments where electromagnetic waves are severely attenuated. This paper presents the design and implementation of a UAC system featuring a microcontroller-based transmitter and receiver setup, equipped with modems and transducers for sound signal transmission. Environmental monitoring is achieved with sensors including temperature, Total Dissolved Solids (TDS), and turbidity sensors to enhance data accuracy in variable underwater conditions. The results indicate the system's potential to transmit data over short distances with moderate reliability, showcasing its applicability for underwater sensor networks and environmental monitoring.

Keywords: Acoustic Communication, Modems, Transduces, water testing Sensors

1. INTRODUCTION

Underwater acoustic communication is a technique of sending and receiving messages in water. There are several ways of employing such communication but the most common is by using hydrophones. Underwater communication is difficult due to factors such as multi-path propagation, time variations of the channel, small available bandwidth and strong signal attenuation, especially over long ranges. Compared to terrestrial communication, underwater communication has low data rates because it uses acoustic waves instead of electromagnetic waves.

With increasing interest in underwater sensor networks for marine research, aquaculture, and environmental monitoring, reliable underwater communication systems are crucial. Acoustic waves are the preferred medium for underwater communication due to their longer propagation distance compared to electromagnetic waves. This research focuses on developing a microcontroller-based underwater acoustic communication system, which can efficiently transmit and receive signals under water, leveraging temperature, TDS, and turbidity data to adapt and improve communication quality. underwater wireless communication is the wireless communication in which acoustic signals (waves) carry digital information through an underwater channel. the signal that are used to carry digital information through an underwater channel are acoustic channel.

2. LITERATURE SURVEY

Optical communication-based system will have the high propagation speed. But suspended particle in water causes back scattering and hence there are affected by the turbidity of the water. Acoustic waves are less sensitive to the suspended fine particles with in water and turbidity than the optical waves. They are the most used methods due to their ability to reach long distances. However, it has some main drawbacks, like low data rate. That data rate is limited by strong reflections and attenuations as well as poor performance inturbidwater with large particles, salinity and environmental sensitivity.

Khalid Mahmoud Awan, et al [1] this paper describes the Underwater sensor network has a number of vehicles and sensors that are deployed in a specific area to perform collaborative monitoring and data collection tasks. Traditionally for the monitoring of ocean bottom, oceanographic sensors are deployed for recording data at a fixed location and recover the instruments at the completion of task. The major disadvantage of this approach is lack of interactive communication between different ends. Major challenges for the design of acoustic network are spectrum sensing, dynamic power control, spectrum sensing strategy, etc. Therefore, routing and media access control protocols need to be designed by taking his care of maximizing the channel utilization.

Abhishek Sharma,et al [2] this paper deals with monitoring different activities in an underwater environment. Due to these reasons, under-water wireless communication has become a significant field. Optical, acoustic and electromagnetic waves are widely used for data transmission. Investigation of possible techniques has a huge impact on wireless communications. Nowadays, this system is being used for experimental observation, , oceanographic data collection and analysis, underwater navigation, disaster prevention and early detection warning of a tsunami.

Mr. Velu Aiyyasamy,et al [3] this paper states that underwater wireless data transmission is of greatinterest as there is a rise in number of devices deployed underwater, that require a very high bandwidth and thus high capacity for data transmission. Several advancements have been made in this field using acoustics but it has limited bandwidth. Electromagnetic waves are an alternative to acoustics. These waves, within the radio frequency range, are a suitable option for underwater wireless communication when used for high-rate transfer over a short range of distance.

Muhammad Tahir, [4] this paper focuses on physical properties that can be observed via electromagnetic radiations which include the following: ocean surface wind stress, surface wave spectra, sea surface topography, sea surface temperature, and sea ice cover, etc. It also deals with the challenges face by electromagnetic waves in underwater environment which includes, Interaction of radio frequency with sea surfaces, emission of radio and microwave energy from the sea surface.

[5]"Angayarkanni S, Arthi R, Nancy S, Sandhiya A, "Underwater Communication Using Li-Fi Technology", 2023. Our diverse team endeavors to provide a thorough exploration of Li-Fi-based underwater communication systems, covering hardware and software dimensions. Li-Fi leverages visible light for data transmission, presenting advantages over conventional RF and acoustic methods underwater. We will delve into system development, deployment, and its potential in tackling underwater communication challenges like vehicle theft and hacking vulnerabilities. With our collective proficiency, we aim to comprehensively assess Li-Fi's strengths, including its high bandwidth, low latency, and bolstered security, highlighting its promise in propelling underwater exploration and surveillance forward."

[6] Mei Yu Soh, Wen Xian Ng, Qiong Zou, Denise Lee, T. Hui Teo, and Kiat SengYeo 2022,."Real-Time Audio Transmission Using Visible Light Communication", 2022. "In our paper titled 'Real-Time Audio Transmission Using Visible Light Communication' published in 2022, our diverse team offers a succinct overview of Li-Fi's utilization in underwater communication, examining both hardware and software facets. Li-Fi harnesses visible light, presenting superior bandwidth and security compared to conventional methods. We explore its potential in mitigating challenges such as underwater vehicle theft and hacking. Leveraging our expertise, we conduct a comprehensive analysis of Li-Fi's evolution, deployment, and its role in driving forward underwater exploration."

[7]. Robert Codd-Downey and Michael Jenkin. "Wireless Teleoperation of an Underwater Robot using LiFi", 2023. "In our paper titled ' Wireless Teleoperation of an Underwater Robot using Li-Fi' published in 2023, our team explores the utilization of Li-Fi for underwater communication, bringing together hardware and software proficiency. Li-Fi's utilization of light facilitates rapid and secure data transmission underwater, presenting remedies for issues such as vehicle theft and hacking susceptibilities. We scrutinize the stages of Li-Fi's development, the hurdles in its implementation, and its potential to revolutionize underwater exploration and bolster security measures."

[8]. Evangelos Pikasis and Wasiu O. Popoola, "Understanding LiFi Effect on LED Light Quality", 2022. " In our paper titled 'Understanding LiFi Effect on LED Light Quality' published in 2022, our team explores the utilization of Li-Fi for underwater communication, bringing together hardware and software proficiency. LiFi's utilization of light facilitates rapid and secure data transmission underwater, presenting remedies for issues such as vehicle theft and hacking susceptibilities. We scrutinize the stages of Li-Fi's development, the hurdles in its implementation, and its potential to revolutionize underwater exploration and bolster security measures."

3. METHODOLOGY

The system consists of a transmitter and receiver, each composed of a microcontroller, modem, and transducer. The transmitter gathers environmental data through sensors, including a temperature sensor, TDS sensor, and turbidity sensor. Data is processed and transmitted acoustically to the receiver, which decodes the signals and translates them for display or further analysis.

1. **Data Collection**: underwater data, critical to understanding underwater communication conditions, is captured by the temperature, TDS, and turbidity sensors.
2. **Signal Transmission**: Using the transducer, the modem converts data into acoustic signals. The microcontroller manages the timing and encoding for efficient data transmission.
3. **Reception and Decoding**: The receiver's transducer captures the transmitted acoustic signal, and the modem converts it back to an electronic signal that is then processed by the microcontroller for interpretation.

Initialize System: The transmitter's microcontroller gathers initial sensor data.

Encode and Transmit Data: Sensor data is encoded, modulated, and sent via the transducer.

Receive and Decode Data: Receiver captures the signal, decodes, and displays the data.

Error Correction: Detected errors are corrected, and data is verified for accuracy

4. BLOCK DIAGRAM

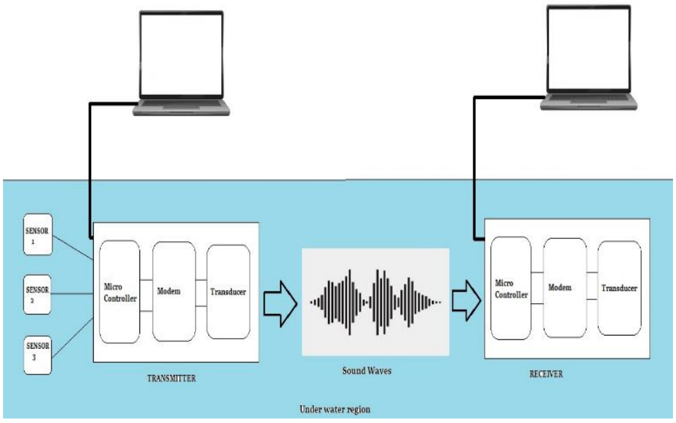

Fig. 1 Block Diagram

5. ALGORITHMS & PROTOCOL

1. **Signal Encoding**: Binary Phase Shift Keying (BPSK) is used to encode data as acoustic signals, as it is resilient to underwater noise.
2. **Error Detection and Correction**: Error correction algorithms, such as Reed-Solomon codes, improve data reliability by correcting small errors caused by underwater turbulence.
3. **Environmental Data Adjustment**: Using readings from temperature, TDS, and turbidity sensors, an adaptive algorithm adjusts signal power and frequency to optimize communication quality.

Flow

1. **Initialize System**: The transmitter's microcontroller gathers initial sensor data.
2. **Encode and Transmit Data**: Sensor data is encoded, modulated, and sent via the transducer.
3. **Receive and Decode Data**: Receiver captures the signal, decodes, and displays the data.
4. **Error Correction**: Detected errors are corrected, and data is verified for accuracy.

Advantages

- Effective in low-range communication applications.
- Ability to adapt signal parameters based on environmental conditions.
- Enhanced accuracy and reliability using sensor input adjustments.

Limitations

- Limited communication range and affected by water turbulence.
- Higher energy consumption due to acoustic transmission.
- Complexity in error correction for highly noisy environments.

Conclusion and Future Scope

This research demonstrates a functional UAC system with environmental adaptability, making it suitable for underwater sensor networks. Future enhancements could focus on multi-node communication setups and power optimization techniques, potentially integrating machine learning models to further refine adaptability to environmental conditions.

An overview of basic principles and constraints in the design of reliable shallow water acoustic networks that may be used for transmitting data from a variety of undersea sensors to onshore facilities. Major impediments in the design of such networks are considered including severe power limitations imposed by battery power, severe bandwidth limitation, channel characteristics including long propagation times, multi path, and signal fading

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