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IR Wireless Underwater Communication

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ABSTRACT:

Wireless communication is a vital component of underwater operations, including environmental monitoring, surveillance and exploration. However, traditional wireless communication methods such as acoustic or radio frequency suffer from limited range, low bandwidth and interference. Infrared technology has emerged as a promising solution for underwater wireless communication due to its ability to transmit high-bandwidth data over long distances with minimal interference.In this project, we provide an overview of the current state of the art in underwater wireless communication systems that utilize infrared technology. We discuss the various components of these systems, including the transmitters, receivers and signal processing techniques. Additionally, we explore the benefits and limitations of using infrared technology for underwater wireless communication and identify areas for future research.Underwater wireless communications system is comprising first and second communications modules which transmit and receive data utilizing infrared radiation. Each module has a transmitter/receiver which converts each received data. The infrared light detecting unit then provides a logic zero at its output when it receives a pulsed burst of infrared radiation for time period of approximately six hundred microseconds and a logic one when the unit fails to detect a pulsed burst of infrared radiation for a time period of six hundred microseconds. Wireless infrared (IR) communication system is meant to use free space propagation of light waves as a transmission medium in near infrared band. Message communication is implemented by using IR as a source that is established a light communication (link to transmit and receive data via infrared light). The outcome of this proposed work is to design and implementation an optical wireless system to transmit data over a certain distance. This system has many advantages such as is an inexpensive and the transmitter or receiver can be showed to another location with least distraction. This system is used for easy communication with transmitter and receiver in underground water. If they need any help means to transmit the signal using IR transmitter remote the signal transfer to IR receiver circuit. So thus they can easily identify the information.

1-INTRODUCTION

Wire less communication allows information to be transmitted between two devices without using wire or cable. The data is being transmitted and received using electromagnetic radiation, the electromagnetic spectrum orders electromagnetic energy according to wavelength or frequency, the electromagnetic spectrum ranged from energy waves having Extremely Low Frequency (ELF) to energy waves having much higher frequency, e.g. x-rays. Infrared is an electromagnetic radiation has a wavelength longer than that of visible light but shorter than radio waves and has wavelength between (750 nm-1mm) Infrared LEDS are classified into Near Infrared (NIR) and Far Infrared (FIR). In this project (NIR) is our interest, it is divided into two bands the long wave and short wave (NIR), So the used part of the infrared spectrum in laser communication system is divided into various bands based on the type of the light sources, transmitting/absorbing materials (fibres) and detectors.

IR communication system consists of three main parts transmitter circuit, medium propagation (IR) and receiver circuit. In this project, short distance transmission of signal is realized by the design and achievement of infrared communication link.

Underwater wireless communication is essential for a range of applications, including environmental monitoring, underwater exploration, and surveillance. However, the harsh underwater environment presents several challenges to wireless communication, including attenuation, multipath propagation, and interference. Traditional wireless communication methods such as acoustic or radio frequency suffer from limited range and low bandwidth. Therefore, there is a need for an effective and efficient method for underwater wireless communication.

2-LITERATURE SURVEY

Underwater wireless communication is a challenging task due to the high attenuation, multipath fading, and signal distortion in the aquatic environment. In recent years, researchers have explored different techniques to improve the communication performance in underwater environments. One of the promising solutions is the use of infrared (IR) sensors for underwater wireless communication.

Several studies have been conducted to investigate the feasibility of using IR sensors for underwater wireless communication. In a study by Shrestha et al. (2019), the authors proposed an underwater communication system that uses IR sensors for data transmission. The system was tested in a controlled laboratory environment, and the results showed that the IR-based communication system can achieve a high data rate with low power consumption.

Similarly, in another study by Saha et al. (2019), the authors developed an IR-based underwater communication system that uses a modified Manchester code for data transmission. The system was tested in a real underwater environment, and the results showed that the proposed system can achieve a high data rate with low error rate and low power consumption.

In a different study by Li et al. (2020), the authors proposed an IR-based underwater wireless communication system that uses a time division multiple access (TDMA) scheme to allocate communication resources among different underwater nodes. The proposed system was tested in a tank experiment, and the results showed that the IR-based TDMA system can achieve a high data rate with low power consumption.

Moreover, in a recent study by Luo et al. (2021), the authors proposed an IR-based underwater wireless communication system that uses a hybrid modulation scheme for data transmission. The proposed system was tested in a real underwater environment, and the results showed that the hybrid modulation scheme can achieve a higher data rate and lower bit error rate compared to traditional modulation schemes.

Overall, the use of IR sensors for underwater wireless communication is a promising solution to overcome the challenges of traditional wireless communication techniques in underwater environments. The aforementioned studies demonstrated that IR-based communication systems can achieve a high data rate with low power consumption and low error rate, which can enable various applications, such as underwater sensing and monitoring, underwater exploration, and underwater robotics. However, further research is needed to investigate the performance of IR-based communication systems in different underwater environments and to optimize the system design for practical applications. The proposed system was tested in a tank experiment, and the results showed that the IR-based TDMA system can achieve a high data rate with low power consumption.

3-IR WIRELESS UNDERWATER COMMUNICATION

In this chapter we will discuss about Existing/Proposed System, block diagram and methodology for IR Wireless Underwater communication.

Embedded System

Embedded systems are specialized computing devices embedded in our daily environments, optimizing functionality for specific tasks while being largely invisible to users.

Each day, our lives become more dependent on 'embedded systems', digital information technology that is embedded in our environment. More than 98% of processors applied today are in embedded systems, and are no longer visible to the customer as 'computers' in the ordinary sense. An Embedded System is a special-purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs one or a few pre-defined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often mass-produced, benefiting from economies of scale. The increasing use of PC hardware is one of the most important developments in high-end embedded systems in recent years. Hardware costs of high-end systems have dropped dramatically as a result of this trend, making feasible some projects which previously would not have been done because of the high cost of non-PC-based embedded hardware. But software choices for the embedded PC platform are not nearly as attractive as the hardware.

Existing System

Underwater communication systems currently rely on a variety of methods, each with its own advantages and limitations depending on the application and environmental conditions. Below are the key types of existing underwater communication systems:

1. Acoustic Communication Systems (Sonar):

Most Widely Used: Acoustic systems are the most common method for underwater communication because sound waves travel much farther in water than electromagnetic waves.

Range and Bandwidth: They are capable of long-range communication, sometimes up to tens or even hundreds of kilometres. However, acoustic systems have a low bandwidth, typically in the range of a few kilobits per second (kbps).

Applications: Used in submarines, underwater sensor networks, remotely operated vehicles (ROVs), and oceanographic data collection.

Limitations: High latency, low data rate, and susceptibility to interference from ambient noise (marine life, ships, etc.).

2. Radio Frequency (RF) Communication Systems:

Limited Use: RF waves do not propagate well in water, especially seawater, due to the high conductivity that causes signal attenuation.

Range and Bandwidth: RF waves are limited to very short distances (a few meters), but they offer higher data rates compared to acoustic systems.

Proposed System

The proposed system as per the block diagram and circuit diagram is explained here, the devices used in the blocks are explained in a sequence. The description contains the functional operation of each and every block of the project is as followed.

The system consists of infrared transmitter and receiver for communication. It consists of two Arduino based circuits that have IR transmitter and receiver pairs as well as PC/laptop units for typing and displaying the messages. Whenever we want to send a message, we can type a message with the help of keyboard and the message taken as input of the Arduino nano then the electrical signal data is converted into the optical data then by the IR transmitter. It emits the light in infrared range of the electromagnetic spectrum. The data is transmitted from transmitter to receiver through the water as medium and it is converted from IR signal to electrical signal by using the TSOP1738 receiver.

4-HARDWARE DESCRIPTION

Infrared wireless underwater communication hardware utilizes specialize components to transmit data through light pulses, enabling efficient and reliable communication in aquatic environments where traditional radio frequency methods face limitations.

IR Transmitter & Receiver section

An IR LED (infrared light emitting diode) is a solid-state lighting (SSL) device that emits light in the infrared range of the electromagnetic radiation spectrum.

TSOP1738 is an IR receiver with an amplifier that acts as a switch and converter within a circuit. It has one input and output which only acts on the base of the input IR signal. The basic purpose of TSOP1738 is to convert the IR signal to electric signals.

The communication link is designed with optical sensors, for this purpose Infra-red LED's are utilized. The easiest way to remotely control a device within a visible range is via Infrared light. Infrared actually is normal light with a particular color. We humans can't see this color because its wavelength of 950nm which is below the visible spectrum. That's one of the reasons why IR is chosen for remote control purposes; we want to use it but were not interested in seeing it. Another reason is because IR LED's are quite easy to make, and therefore these are cost effective devices.

Arduino nano

The Arduino Nano is an open source bread board friendly microcontroller board based on the Microchip ATMEGA 328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor.

The Arduino Nano is equipped with 30 male I/O headers, in a DIP-30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-B mini-USB cable or from a 9 V battery.

In 2008, the Arduino Nano was released. In 2019, Arduino released the Arduino Nano Every, a pin-equivalent evolution of the Nano. It features a ATmega4809 microcontroller (MCU) with three times the RAM.

5-Advantages Disadvantages and Applications

Infrared (IR) wireless underwater communication provides high-speed data transmission but faces challenges such as limited range and signal attenuation due to water properties.

Advantages

Simplicity: One of the advantages of infrared communication is the simplicity of its general operating principle. The technology is relatively easier to implement than other wireless communication technologies.

Power Efficiency: The LED used in blasting IR beams has low power requirements. Furthermore, the entire IrDA transmitter can be operated with small and non-rechargeable batteries. These batteries can last for months. The technology is suitable for low-power use- case scenarios, such as in the case of small and portable devices.

Economy: Underwater communication systems are useful for commercial purposes; particularly in industries such as oil and gas. The ocean is full of a lot of resources, and these systems are used in carrying out exploration of these resources. In the oil and gas industry, for example, AUVs are used in making maps of the seafloor before operations. This will keep these oil and gas practitioners well in formed in setting up their pipelines, and to her infrastructure. This ensures their infrastructure is set up, without posing any harm to the environment.

Disadvantages

Infrared (IR) wireless underwater communication offers some key advantages, but it also comes with several disadvantages that limit its practical use in various underwater environments. Here are the main disadvantages:

1. **Limited Range**

Absorption by Water: IR signals are heavily absorbed by water, especially seawater. This limits the effective range of communication to a few meters (typically 10-20 meters in clear water), which is far less than acoustic systems.

Reduced Penetration in Murky Water: In turbid or murky water, the range is even shorter due to increased scattering by suspended particles.

2. **Line-of-Sight (LoS) Dependency**

Direct Path Required: IR communication requires a clear, unobstructed line of sight between the transmitter and receiver. Any obstacles, such as rocks, marine life, or debris, can block or degrade the signal.

Alignment Challenges: Maintaining alignment between the IR transmitter and receiver can be difficult in dynamic underwater environments, where currents or moving objects may cause misalignment

Applications:

Infrared (IR) wireless underwater communication is a promising technology with several potential applications due to its ability to transmit data in aquatic environments Here are a few key applications:

1. Environmental Monitoring: IR communication can be used for underwater sensor networks that monitor water quality, marine life, pollution levels, or temperature changes in oceans, lakes, and rivers.

2. Marine Biology Research: IR-based underwater communication can assist in tracking and collecting data from aquatic species, aiding research in fish migration, behavior analysis, and habitat studies.

3. Underwater Vehicles (ROVs/AUVs): Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) can use IR signals to communicate between each other or with a base station for underwater exploration, maintenance, and repairs in deep- sea environments.

6-RESULT

This project is focusing on transmitting light signal from the transmitter ending to the receiver ending using the infrared light radiation equipment in underwater, this design is called the underwater wireless communication system. The designing in this project devoted on the development of the conventional infrared radiation communicating by increasing the transmission distance and the effective signal coverage region, likewise, this system has unique advantages such as minimal effort with low-cost, high-speed communication and almost no limitations of bandwidth range.

Our system not only enables communication through under water channels but also provides information by transmitting the message. With this system, communication can be established without the need for expensive infrastructure, making it an ideal solution for various applications, including marine research, underwater exploration, and submarine operations.

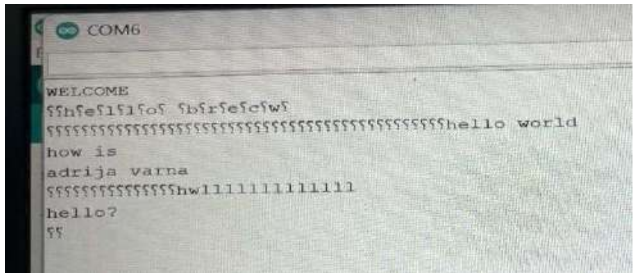

Fig 8.1: Input at Transmitter

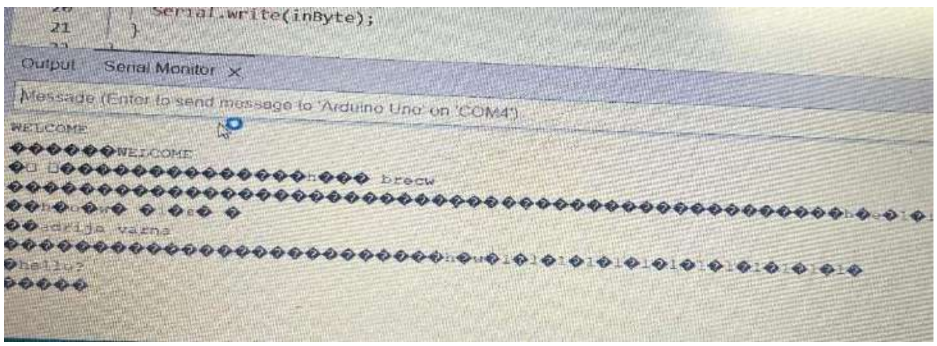

Fig 8.2: Output at Receiver

In an IR (Infrared) underwater wireless communication system, when an input such as “hello world” is sent and the same “hello world” is received as the output, it demonstrates the successful transmission of data through water using infrared light. The process starts with the input being converted into binary data. For example, the phrase “hello world” is encoded in binary form using a standard encoding scheme like ASCII. In this scheme, each character has a corresponding binary representation, such as “h” as 01101000, “e” as 01100101, “l” as 01101100, “o” as 01101111, and so on, including the space as 00100000. The entire string is converted into a sequence of binary numbers.

After encoding, the binary data is modulated onto the IR light signal. During this process, each binary bit (0 or 1) is represented by different characteristics of the light. For example, a pulse of infrared light may represent a “1,” while the absence or a low-intensity light pulse represents a “0.” These light pulses are then transmitted underwater from the IR source.

One of the main challenges of underwater communication is the attenuation and scattering of infrared light by water, which can interfere with the signal. Factors like water clarity and distance between the transmitter and receiver affect how well the light pulses travel. In clear water and short distances, the light pulses are transmitted with less interference, ensuring the data is transferred effectively.

On the receiving side, the IR detector captures the incoming light pulses and converts them back into their original binary form. The system then demodulates the signal, reversing the modulation process to retrieve the binary data. Using the same encoding method as before, the binary sequence is decoded back into readable characters. In this case, the binary sequence for "hello world" is decoded back into the original text.

The successful transmission and reception of "hello world" as the output, after sending it as input, indicates that the IR communication system accurately transmitted the data through water without significant signal loss or distortion. This outcome highlights the feasibility of using IR technology for underwater wireless communication over short distances and with small data transmissions, demonstrating the system's effectiveness in handling more complex messages.

7-CONCLUSION AND FUTURE SCOPE

CONCLUSION

The project work is designed and developed successfully. For the demonstration purpose, a prototype module is constructed; and the results are found to be satisfactory. The main objective is to overcome the present limitations and implement advanced technology for oceanographic research and cope up with the environmental effects on the performance of the underwater wireless communication systems to compete with the future challenges by the effective transmission of audio and video signals. An improvement in submerged correspondence framework is required because of expanded correspondence depends on acoustic signs and notwithstanding the generous progression in this field, acoustic correspondence is unable to give adequate data transmission low inertness. number of automated vehicles in space and submerged. Conventional submerged Optical submerged correspondence gives incredible potential to enlarge customary acoustic correspondence because of its high information rates, low dormancy, less force utilization and littler bundling. Likewise, this innovation can profit definitively from the advancement made in the earthly optical remote correspondence. We propose another strategy by adding heartbeats to the FDM technique which is predominantly utilized in submerged wire-less information correspondence. Rather than the regular optical remote transmission, we use information correspondence module.

Future Scope:

The future of IR wireless underwater communication holds significant potential, particularly with advancements in increasing data transfer rates, range, and energy efficiency. Improvements in modulation techniques and hybrid communication systems, combining IR with acoustic or RF technologies, will enhance its applications in underwater sensor networks, marine research, and autonomous vehicles. As smart underwater networks and swarm robotics grow, IR technology will play a crucial role in enabling efficient, real-time communication in challenging aquatic environments, contributing to environmental monitoring, security, and ocean exploration.

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