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ACCREDITED BY NBA AND NAAC WITH 'A++' GRADE

Deptartment of Electronics & Telecommunication Engineering

A REPORT

ON

"UNDERWATER DATA TRANSMISSION USING LI-FI TECHNOLOGY"

B.E. (E&TC)

SUBMITTED BY

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UNDER THE GUIDANCE OF

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(Academic Year: 2023-2024)

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Certificate

This is to certify that project entitled

"UNDERWATER DATA TRANSMISSION USING LI-FI TECHNOLOGY"

has been completed by

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of BE E&TC in the Semester - I of academic year 2023-2024 in partial fulfillment of the Fourth Year of Bachelor degree in "Electronics & Telecommunication Engineering" as prescribed by the Savitribai Phule Pune University.

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Place: MESWCOE, Pune.
Date : 22/11/2023

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Thanking You,

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Abstract

In the present scenario for various industrial, scientific and underwater applications high speed wireless communication is desirable. The existing underwater communication technique such as acoustic communication method has high latency and suffer low data rates, whereas RF frequency communication have high attention of signal underwater. The emerging optical wireless communication techniques have offered high data rates in Gbps and visible light promises low attenuation of signal strength which provides high data density. The proposed method deals with the transmission of data underwater through visible light communication. The proposed method designs data transmission model where it transmits text, audio, image through water. The hardware used in this model are Arduino Nano and the transmitter part in the model is the laser light, whereas the receiver part is made of laser receiver. The transmitter follows On Off Keying (OOK) modulation technique where the blinking of laser on determine1's and off as 0's in this way the data is transmitted via line of sight to the receiver underwater. Li-Fi implementation can be executed to achieve rapid information move. In future, the capacity can be increased as per the requirement to transmit high quality image audio using higher rage lasers and photodiodes.

Chapter 1

INTRODUCTION

1.1 Overview

In the recent years where technology has been ruling the world with its high-speed internet services, optical wireless communication can play a crucial role in this sector. Optical wireless communication is capable of providing high data rates with low power and mass requirement and is used in various industrial, space and underwater communication applications. Underwater optical wireless links are less explored as it is more challenging where various physical parameters are to be considered for the data transmission as the underwater environments vary forms hallow water bodies to deep oceans. The present technology using acoustic waves for underwater communication links has limited performance due to low bandwidth, high transmission losses, time varying multipath propagation, high latency and doppler spread. These factors lead to temporal and spatial variation of acoustic channel which in turn limits the available bandwidth of the system [1]. It can support data rate up to tens of kbps for long distances (ranging in kms) and up to hundreds of kbps for short distances (few meters). All this has led to the conception of underwater optical wireless communication (UOWC), as it provides higher data rates than the traditional acoustic communication systems with significantly lower power consumption and simpler computational complexities for short-range wireless links [2]. UOWC has different potential applications ranging from deep oceans to coastal waters. Light Fidelity (Li-Fi) is the most reliable means of underwater communication for data transmission. This paper determines the better model for underwater data transmission. This model uses visible light source such as LEDs or laser are used as transmitter and photodiodes like LDR or laser receiver are used as a receiver. The visible light source used in this model is the laser transmitter module and laser receiver on the receiver part. The data to be transmitted is processed through Arduino into 1's and 0's and it follows On Off Keying (OOK) modulation [3]. The blinking of laser on determines 1's and off as 0's, in this way the data is transmitted via line of sight to the receiver underwater. Once the data is received is processed to get the information which can be a text, audio or image. This can be a feasible means of communication between the submarines, autonomous underwater vehicles (AUV) and unmanned underwater vehicles (UUV) as it provides high data rates in the range of Gbps.

1.2 Motivation

Traditional radio waves struggle to penetrate water, making communication challenging for underwater devices. Li-Fi, which uses light to transmit data, can be a promising solution as light travels well in water, allowing for faster and more reliable data transmission compared to conventional methods. This technology has the potential to revolutionize underwater communication for various applications such as oceanography, underwater exploration, and monitoring underwater infrastructure.

1.3 Necessity

The necessity for underwater audio and data transmission using Li-Fi technology arises from the inherent challenges posed by traditional communication methods in aquatic environments. Conventional acoustic communication, while functional, often suffers from limitations such as low data transfer rates, significant latency, and susceptibility to interference in underwater settings. Li-Fi, utilizing light waves for data transmission, addresses these challenges by providing high-speed communication, reduced latency, and increased bandwidth. In underwater scenarios where real-time data is critical for applications ranging from scientific research to defense and industry, Li-Fi emerges as a crucial solution. Its resistance to interference, improved security features, and energy efficiency further enhance its suitability for underwater communication needs. Additionally, the compactness and integration capabilities of Li-Fi components contribute to the development of streamlined and energy-efficient underwater devices, enabling prolonged operational life and supporting advancements in underwater exploration, monitoring, and connectivity. Overall, the necessity for underwater audio and data transmission using Li-Fi technology lies in its ability to overcome the limitations of traditional methods, ushering in a new era of efficient, secure, and high-performance communication beneath the waves.

Chapter 2

LITERATURE SURVEY

1 In this project data is transmitted by modulating the intensity of the light, which is then received by a photosensitive detector, and the light signal is demodulated into electronic form. White LED's used in the head and tail lights can effectively be used for short range communication with the photo detectors.

2 VLC refers to data transmission using visible light between 400 to 800 THz. The bandwidth of VLC is certainly much greater than the bandwidth of radio frequencies, which range from 3KHz to 300GHz. Audio is transmitted through the optical channel established between the LED and the photodiode module using OOK modulation.

3 Li-Fi system can be used to provide short-range tele- operational control of an underwater vehicle. It is used to communicate underwater at distances up to 5m under favorable lighting conditions using visible light.

4 We present a framework for estimating the expected variations in the emitted light quality of illumination LEDs due to Li-Fi.

5 A novel bidirectional underwater visible light communication (BiUVLC) is proposed. The VLC transmitter transmits an information signal using the one of RGB LED through the water tank that represents an underwater environment and then is received by VLC receiver via a color filter.

6 The system able to send text and image data perfectly with maximum transmission distance is 98 cm. The maximum acceptance angle for transmission is 70o with maximum baud rate is 19200 bps. The quality of the system for text transmission is measured by calculating character error rate (CER), while the quality of image transmission is calculated by using Bit Error Rate (BER).

7 The system consists of a transmitter that directs light beam in the direction of the receiver, thereby, converting the electrical data signal into optical signal. Transmitter accepts data over a serial interface which is encoded according to the specification and light pulses generated through LED's. Receiver detects the optical signal and transforms it into electrical signal.

8 In this technology has increased speed, improved bandwidth, and reduced noise. Thus, the audio signal transmitting with the use of Li-Fi. Initially, the voice signal is converted into digital values and these digital data values are converted

to RGB values. RGB values obtained are transmitted as light waves of receiver submarines.

9 Image transmission between two devices is done by using the medium of visible light of electromagnetic spectrum. In Li- Fi basically we focus to transmitting multimedia data between two terminals using LED's. Li-Fi is a transmission of data through illumination, in which data can be sent through a LED light bulb that varies in intensity faster than human eye can follow.

10 In this project Under water is the communication medium. A small 20 micro meter white LED is the source of light and the silicon-based photo diode is used for the realization of the system. LASER can also be used as an alternative for LED. The transmitter will be sending signal pulses. This light is allowed to fall in the photo diode and by using the interference filter, any possible stray of radiation can be emitted.

11 Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi. Important factors we should consider while designing Li-Fi as following: (1) Presence of Light (2) Line of Sight (Los) (3) For better performance use fluorescent light and LED.

12 Author will discuss the audio transfer technology through visible light. The proposed system explains Li-Fi technology is employed as wireless medium to achieve machine movements according to the operator's voice using speech recognition algorithm. The micro-controller will transmit command through the Li-Fi medium. The LEDs are used for the transmission of light giving a range of around 12-15 cm. The range can be increased by multiple other light sources like bulb, laser.

13 The authors will discuss the technology in detail and also how Wi-Fi can be replaced by Li-Fi. Wi-Fi is useful for general wireless coverage within buildings while Li-Fi is ideal for high density wireless data coverage in confined areas where there are no obstacles.

14 The data is sent in the way of light rays that has been generated using LED light source the intensity of the light source as been increased by reducing the amplitude of the digital data that as to be transmitted.

15 This paper discusses a novel idea for Transmission of voices in a real time underwater so that the system can be used by the deep-sea divers for both lightning and data transfer applications simultaneously. Main blocks in the transmitter module are microphone with an amplifier, modulator, LED driver and a power supply block. The audio signal is detected by using a miniature microphone.

Chapter 3

OBJECTIVES

The objectives of a research study on underwater audio and data transmission using Li-Fi technology should be aligned with the specific goals and challenges associated with this application. Here is a list of potential objectives that you might consider for such a study:

1. **Assess the Feasibility of Underwater Li-Fi:**
   - Evaluate the feasibility of implementing Li-Fi technology for audio and data transmission in underwater environments.
2. **Investigate Li-Fi Performance in Different Water Conditions:**
   - Examine how Li-Fi performs under varying water conditions, considering factors such as clarity, salinity, and temperature.
3. **Optimize Li-Fi Communication Parameters:**
   - Identify and optimize key parameters, such as modulation schemes, transmission frequencies, and power levels, to enhance the performance of underwater Li-Fi communication.
4. **Enhance Data Transfer Speed and Bandwidth:**
   - Investigate methods to improve data transfer speeds and increase bandwidth capacity for underwater Li-Fi communication, ensuring support for high-volume data transmission.
5. **Evaluate Latency and Real-Time Communication:**
   - Assess the latency of Li-Fi communication in underwater scenarios and explore techniques to minimize latency, particularly for real-time applications.

Chapter 4

PROPOSED METHODOLOGY

Designing an effective methodology for underwater data and audio transmission using LiFi (Light Fidelity) technology involves a multifaceted approach. The initial step is the careful selection of appropriate light sources, considering factors such as power efficiency and the spectral characteristics of light suitable for underwater communication. The design of efficient photodetectors capable of converting modulated light signals into electrical signals in underwater conditions is paramount. Modulation techniques, such as Orthogonal Frequency Division Multiplexing (OFDM), need to be explored and adapted to accommodate the unique challenges of underwater communication.

To address the underwater channel's complexities, the methodology includes thorough channel characterization, considering factors like signal attenuation, scattering, and absorption. The selection of robust data encoding methods and modulation schemes is crucial to handle these challenges effectively. Implementing error correction techniques ensures data integrity, while mechanisms for localization and synchronization are developed to establish reliable communication links.

Testing and validation play a significant role, involving controlled experiments in underwater environments to assess data rates, signal reliability, and the impact of environmental conditions. Security considerations, including encryption and authentication, are integrated to safeguard transmitted data, particularly in sensitive applications. The methodology also explores integration possibilities with existing underwater sensor networks and communication systems, emphasizing compatibility and enhanced functionality.

Chapter 5

BLOCK DIAGRAM

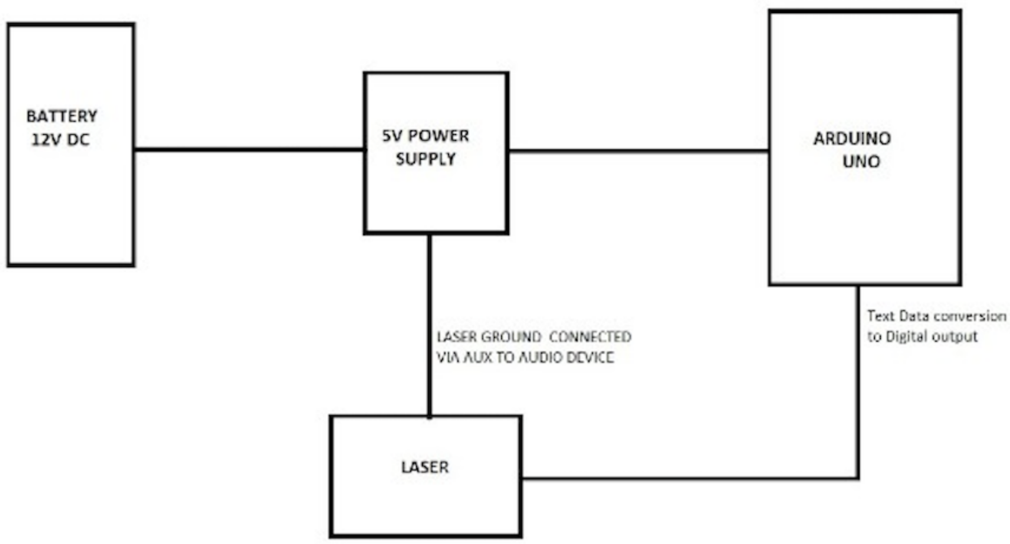

Figure 5.1: TRANSMITTER

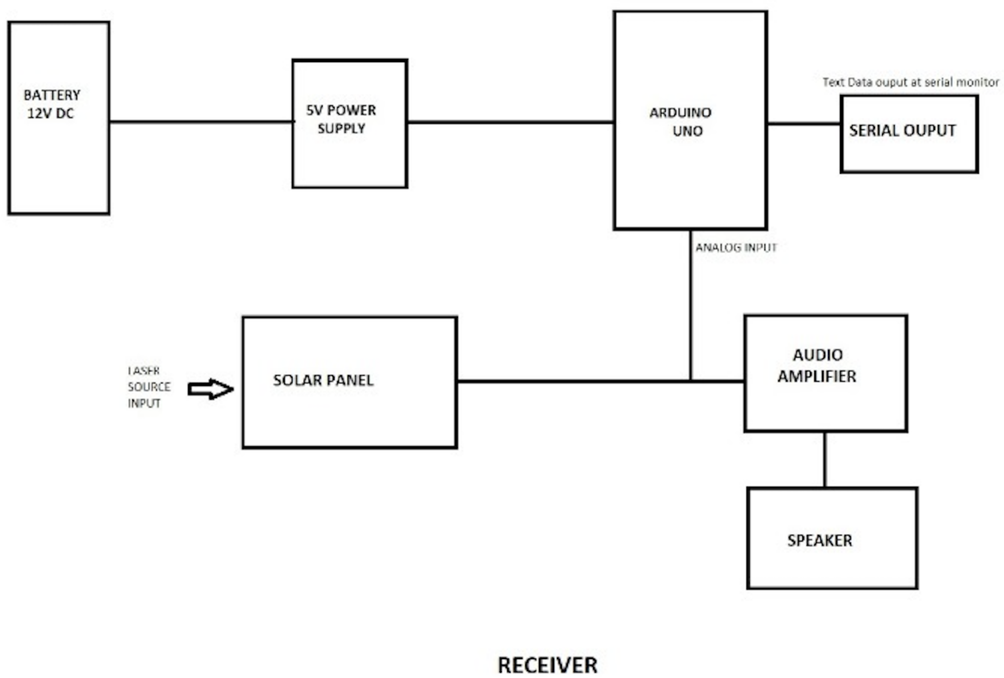

Figure 5.2: RECEIVER

Chapter 6

SOFTWARE REQUIREMENT

6.0.1 IDE used :

[1] Arduino IDE:

The Arduino IDE (Integrated Development Environment) serves as a foundational tool for enthusiasts, makers, and professionals engaged in embedded systems and microcontroller programming. Offering a seamless and user-friendly experience, the IDE simplifies the process of writing, editing, and uploading code to Arduino microcontrollers. Its code editor features syntax highlighting, aiding in code readability, and a syntax checker to identify errors before the code is uploaded to the Arduino board. Users can select the specific Arduino board they are working with and designate the communication port, ensuring seamless connectivity. The IDE also incorporates a Serial Monitor, a valuable tool for debugging and real-time data monitoring between the computer and the Arduino board.

6.0.2 Embedded C:

Embedded C is a specialized programming language tailored for the development of embedded systems—dedicated computing systems integrated into larger devices to perform specific functions. These systems are prevalent in diverse applications, ranging from microcontrollers in consumer electronics to intricate control systems in automotive and industrial machinery. Embedded C is a variant of the standard C programming language, adapted to meet the unique constraints and demands of embedded systems.

Chapter 7

HARDWARE REQUIREMENT

7.1 ARDUINO UNO

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your Uno without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.//

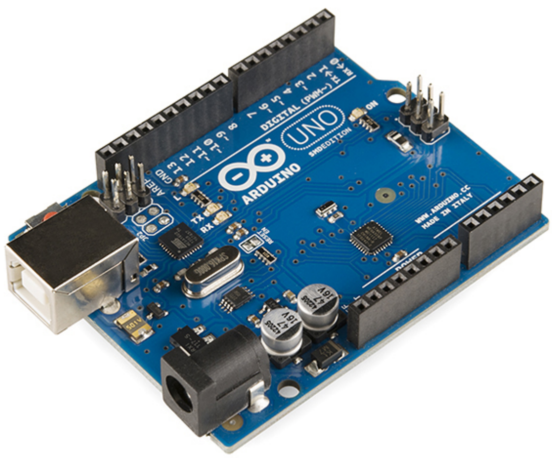

Figure 7.1: Arduino Uno

7.2 ATMEGA-328

The ATmega328 is a microcontroller chip that plays a central role in the world of embedded systems and microcontroller programming. Manufactured by Atmel (now a part of Microchip Technology), the ATmega328 is a part of the AVR (Advanced Virtual RISC) family of microcontrollers. It is widely known for its use in the Arduino Uno, one of the most popular development boards in the maker and electronics community.

At the heart of the ATmega328 is an 8-bit AVR microcontroller with flash memory, EEPROM, and SRAM. Its architecture is optimized for embedded applications, making it versatile for a range of projects. With a clock speed of up to 20 MHz, it provides a balance between performance and power efficiency.

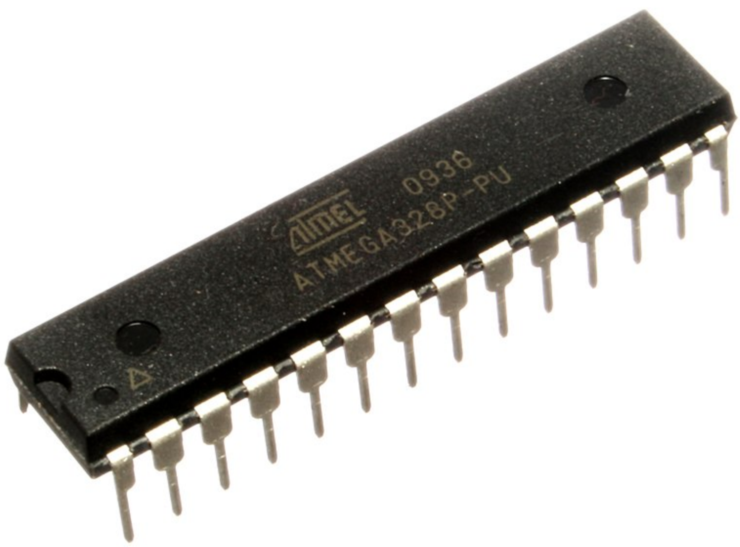

Figure 7.2: AT MEGA-328

7.3 AUDIO AMPLIFIER

An audio power amplifier (or power amp) is an electronic amplifier that amplifies low-power electronic audio signals such as the signal from radio receiver or electric guitar pickup to a level that is high enough for driving loudspeakers or headphones. Audio power amplifiers are found in all manner of sound systems including sound reinforcement, public address and home audio systems and musical instrument amplifiers like guitar amplifiers. It is the final electronic stage in a typical audio playback chain before the signal is sent to the loudspeakers.

The preceding stages in such a chain are low power audio amplifiers which perform tasks like pre-amplification of the signal (this is particularly associated with record turntable signals, microphone signals and electric instrument signals from pickups, such as the electric guitar and electric bass), equalization (e.g., adjusting the bass and treble), tone controls, mixing different input signals or adding electronic effects such as reverb. The inputs can also be any number of audio sources like record players, CD players, digital audio players and cassette players. Most audio power amplifiers require these low-level inputs, which are line level.

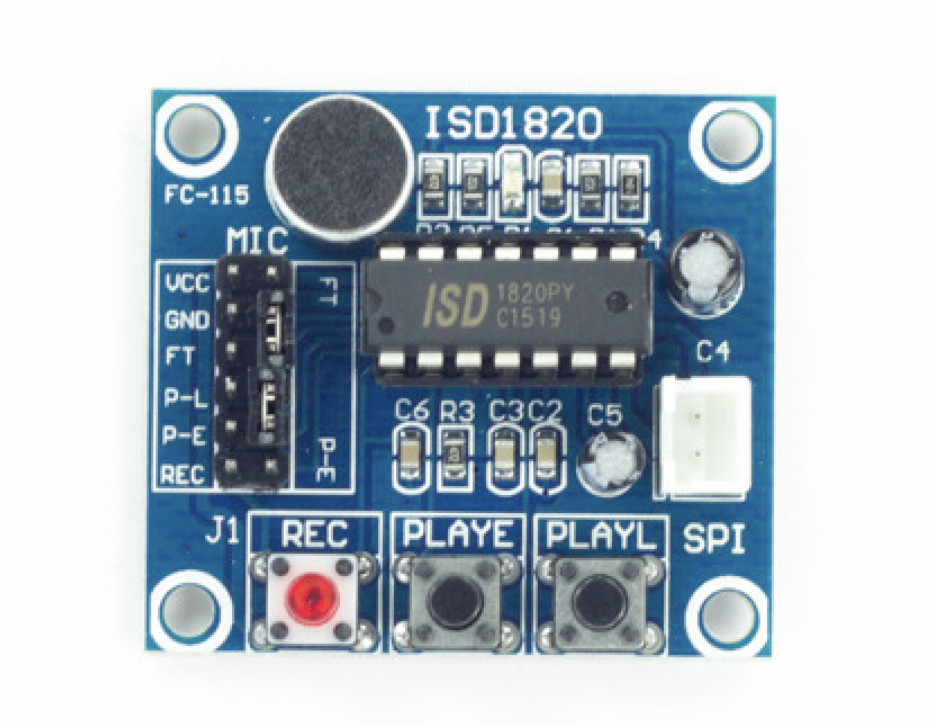

Figure 7.3: Audio Amplifier

7.4 LASER

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The word "laser" is an acronym[1][2] for "light amplification by stimulated emission of radiation".[3][4][5] The first laser was built in 1960 by Theodore H. Maiman at Hughes Research Laboratories, based on theoretical work by Charles Hard Townes and Arthur Leonard Schawlow.

A laser differs from other sources of light in that it emits light which is coherent. Spatial coherence allows a laser to be focused to a tight spot, enabling applications such as laser cutting and lithography. Spatial coherence also allows a laser beam to stay narrow over great distances (collimation), enabling applications such as laser pointers and lidar. Lasers can also have high temporal coherence, which allows them to emit light with a very narrow spectrum. Alternatively, temporal coherence can be used to produce ultrashort pulses of light with a broad spectrum but duration's as short as a fem to second.

Figure 7.4: Laser

7.5 SOLAR PANEL

A solar panel, or photo-voltaic (PV) module, is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy to generate direct current electricity. A collection of PV modules is called a PV panel, and a system of PV panels is called an array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

Solar panels, also known as photovoltaic (PV) panels, are devices designed to harness sunlight and convert it into electricity. Composed of multiple solar cells, typically made of silicon, solar panels utilize the photovoltaic effect to generate an electric current when exposed to sunlight. These cells can be of different types, including monocrystalline, polycrystalline, or thin-film, each with its own set of characteristics. The key function of solar panels is to capture solar energy and transform it into direct current (DC), which is then converted into usable alternating current (AC) by an inverter. Installed on rooftops or open areas with optimal sunlight exposure, solar panels contribute to clean and renewable energy production, reducing reliance on fossil fuels and lowering greenhouse gas emissions. The environmental benefits, coupled with advancements in technology and decreasing costs, have led to a widespread adoption of solar panels globally. Governments often incentivize their use through subsidies and tax credits, fostering a transition towards sustainable energy solutions. Regular maintenance, such as cleaning and occasional system checks, ensures the efficient and prolonged operation of solar panels. Overall, solar panels play a crucial role in the pursuit of cleaner and more sustainable energy alternatives.

Figure 7.5: Solar Panel

7.6 SPEAKER

A speaker is an essential component of audio systems designed to convert electrical signals into audible sound. Comprising components such as a diaphragm, voice coil, magnet, and frame, speakers operate on the principle of electromagnetic induction. The diaphragm, often in the form of a cone or dome, is connected to a voice coil. When an electrical signal, representing audio information, passes through the coil, it interacts with a magnetic field produced by a magnet, causing the diaphragm to vibrate. These vibrations generate sound waves that reproduce the original audio content. Speakers come in various types, including dynamic, piezoelectric, and electrostatic, each with distinct mechanisms for sound production. The quality of a speaker is assessed based on factors such as frequency response, impedance, power handling, and the design of speaker enclosures. Proper matching of speaker impedance with the audio source, along with considerations of frequency range and power capacity, ensures optimal performance in delivering clear and accurate sound reproduction. Whether integrated into audio systems, headphones, or other devices, speakers play a fundamental role in our auditory experience, allowing us to enjoy music, movies, and various forms of communication.

Figure 7.6: Speaker

Chapter 8

WORKING

Here in our project we are sending audio and data over laser light to solar panel For Audio signal transmission, the positive end of laser is connected to 5v supply, ground of laser is connected to aux cable to audio device, also to output of voice recording module, the signal amplitude variations are transmitted to solar panel via laser light, the solar panel output is connected to amplifier circuit i.e. connected to speaker.

For Data transmission laser source is connected to Arduino uno microcontroller, the text data is converted to digital output in 1 , 0 forms to the solar panel . At receiving side solar panel, the analog output of Arduino uno, then the output character data is taken out via serial monitor.

Underwater data and audio transmission using LiFi (Light Fidelity) technology operates on the principles of visible light communication adapted to the challenges of underwater environments. In this innovative approach, light signals, typically emitted by high-intensity LEDs, are utilized to transmit data. The process begins with the modulation of the light signals, a crucial step where the information to be transmitted is encoded onto the light waves. Various modulation techniques, such as OFDM (Orthogonal Frequency Division Multiplexing), are employed to ensure the efficient representation of data in the underwater medium.

The modulated light signals then propagate through the water, where they encounter challenges such as signal attenuation, scattering, and absorption. The underwater channel characteristics are carefully characterized to understand and mitigate the effects of these challenges. Efficient photodetectors, strategically placed to receive the modulated light signals, play a pivotal role. These devices are designed to convert the received light signals into electrical signals, faithfully reconstructing the encoded information.

Chapter 9

APPLICATIONS

Underwater data and audio transmission using LiFi (Light Fidelity) technology holds promise for various applications, leveraging the advantages of visible light communication in challenging underwater environments. Some notable applications include:

1. **Underwater Communication Networks:**

   LiFi can be employed to establish robust communication networks for underwater applications, facilitating data exchange between submerged devices and sensors. This is particularly valuable for oceanographic research, environmental monitoring, and underwater exploration.

2. **Subsea Monitoring and Surveillance:**

   LiFi-enabled underwater communication supports real-time monitoring and surveillance of subsea environments. It can be used for monitoring marine life, tracking underwater vehicles, and ensuring the security of critical infrastructure such as underwater pipelines and cables.

3. **Autonomous Underwater Vehicles (AUVs):**

   LiFi technology can enhance communication capabilities for AUVs, enabling them to transmit and receive data, including navigation instructions and sensor readings, while submerged. This is essential for the autonomous operation and coordination of underwater vehicles.

4. **Offshore Oil and Gas Industry:**

   LiFi communication can improve data transmission in offshore oil and gas operations. It facilitates reliable communication between underwater sensors, monitoring equipment, and surface installations, contributing to the efficient and safe operation of offshore facilities.

5. **Environmental Research and Monitoring:**

   LiFi-based communication systems support underwater environmental research by enabling the transmission of data from sensors measuring parameters such as temperature, pressure, and water quality. This is crucial for studying ecosystems and climate patterns.

Chapter 10

Advantages and Disadvantages

10.1 Advantages:

- **Higher Data Rates:**

  LiFi technology enables high data rates, allowing for faster and more efficient transmission of data and audio signals underwater.

- **Low Latency:**

  LiFi systems can achieve low latency, ensuring minimal delays in the transmission of data and audio.

- **Immunity to Electromagnetic Interference:**

  LiFi operates in the visible light spectrum and is not susceptible to electromagnetic interference, making it a reliable option for communication in environments where traditional radio-frequency-based technologies may experience disruptions.

- **Higher Security:**

  LiFi offers enhanced security for underwater communication due to the directional nature of light.

- **No Risk of Radio Frequency (RF) Pollution:**

  LiFi technology does not contribute to RF pollution, which can be a concern in densely populated frequency bands.

10.2 Disadvantages:

- **Limited Range:**

  LiFi signals have a limited range underwater compared to radio frequency signals. Light signals may experience significant attenuation in turbid water, reducing the effective communication distance.

- **Dependency on Line of Sight:**

  LiFi relies on line-of-sight communication, meaning that obstacles or bends in the underwater environment can obstruct the transmission of light signals.

- **Sensitivity to Water Conditions:**

  Water conditions, such as turbidity and suspended particles, can affect the performance of LiFi.

- **Challenges in Murky Water:**

  In murky or heavily sedimented water, LiFi signals may struggle to penetrate and maintain clarity. This can result in reduced data rates and increased susceptibility to signal loss.

- **Environmental Factors:**

  Natural factors such as ambient light variations, water currents, and water temperature changes can impact the performance of LiFi systems, requiring additional adaptations and adjustments for reliable communication.

Chapter 11

FUTURE SCOPE

The future scope of underwater audio and data transmission using Li-Fi technology holds immense promise for revolutionizing communication in aquatic environments. Anticipated advancements include substantial increases in data transfer speeds, enabling more efficient and rapid communication for underwater applications. As Li-Fi technology evolves, we can expect its integration with underwater autonomous systems, leading to more sophisticated underwater exploration and research missions. The emergence of underwater Internet of Things (IoT) networks, facilitated by Li-Fi, may revolutionize real-time data exchange among underwater sensors, enabling advanced monitoring of marine environments and infrastructure. Research and innovation are likely to extend the range and coverage of Li-Fi in underwater settings, addressing challenges related to depth, distance, and varying water conditions. The establishment of standardized protocols and enhanced security features specific to underwater Li-Fi is expected, fostering interoperability and secure data transmission. Commercial sectors, including oil and gas, shipping, and telecommunications, may witness widespread adoption of Li-Fi, contributing to safer and more efficient underwater operations. The collaboration of researchers, institutions, and industries globally may lead to the development of a comprehensive and interconnected global underwater communication network. Advances in Li-Fi components and their adaptation for challenging underwater environments, such as deep-sea exploration, are also on the horizon. As the technology progresses, underwater Li-Fi could play a vital role in disaster response scenarios, providing reliable communication during emergencies or natural disasters.

Chapter 12

CONCLUSION

The possibilities are numerous and can be explored further. If his technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio-based wireless isn't allowed such as aircraft or hospitals. One of the shortcomings however is that it only works in direct line of sight.

Chapter 13

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