LI-FI based under water communication

A Project report submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

in

ELECTRONICS AND COMMUNICATION ENGINEERING

By

B. V. SATYA ANAND	**21NU1A0416**
B. VAMSI REDDY	**22NU5A0404**
ABDUL AYESHA	**21NU1A0401**
G. ABHISHEK BABU	**21NU1A0442**
D. YASWANTH SAI	**21NU1A0427**

Under the Guidance of

Mr. K. S. V. Ramanaji, M. Tech

Assistant Professor

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
NADIMPALLI SATYANARAYANA RAJU INSTITUTE OF TECHNOLOGY
(Autonomous)
SONTYAM, VISAKHAPATNAM-531173

2024-2025

NADIMPALLI SATYANARAYANA RAJU INSTITUTE OF TECHNOLOGY
(Autonomous)
SONTYAM, VISAKHAPATNAM-531173
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that the Project Work entitled "**LI-FI BASED UNDER WATER COMMUNICATION**" that is being submitted by **B.V.SATYA ANAND (21NU1A0416), B.VAMSI REDDY (22NU5A0404), ABDUL AYESHA (21NU1A0401), G.ABHISHEK BABU (21NU1A0442), D.YASWANTH SAI (21NU1A0427)** for fulfilment of the requirements for the award of degree of **BACHELOR OF TECHNOLOGY in ELECTRONICS AND COMMUNICATION ENGINEERING** to Jawaharlal Nehru Technological University-Vizianagaram is a record of Bonafide work carried out by them under my guidance and supervision.

Project Guide	**Head of the Department**
Mr. K. S. V. Ramanaji	**Dr. B. Siva Prasad**
Assistant Professor	**Professor**

INTERNAL EXAMINER **EXTERNAL EXAMINER**

EXTERNAL EXAM DATE: ___________

DECLARATION

We declare that this project entitled "**LI-FI BASED UNDER WATER COMMUNICATION**" has been carried out by our batch have been presented in the form of dissertation in partial fulfilment of the requirements for the award of the degree of **BACHELOR OF TECHNOLOGY** in **ELECTRONICS AND COMMUNICATION ENGINEERING**.

We further declared that this dissertation has not been submitted elsewhere for any degree.

21NU1A0416	**B. V. SATYA ANAND**
22NU5A0404	**B. VAMSI REDDY**
21NU1A0401	**ABDUL AYESHA**
21NU1A0442	**G. ABHISHEK BABU**
21NU1A0427	**D. YASWANTH SAI**

ACKNOWLEDGEMENT

“Gratitude is the memory of heart “goes saying. Expressing heartful thanks is always a pleasant duty.It will be a pleasure for us expressing my deep sense of gratitude and sincere thanks to our guide,

Mr. K.V.S Ramanaji, Assistant Professor of **N. S. Raju Institute of Technology**, for his excellent guidance and enthusiastic encouragement in motivating us to take up this challenging task. Especially the extensive comments, the discussions and interactions with her had a direct impact on the final form and quality of this thesis.

We are thankful to our beloved Project Coordinator **Dr. K. Rajasekhar, Associate** Professor of **N.S. Raju Institute of Technology**, for providing facilities and continuous support to complete the project.

We wish to express deep gratitude to **Dr. B. Siva Prasad**, Professor, Head of the Department of Electronics and Communication engineering, N S Raju Institute of Technology, for providing generous assistance, encouraging and spending many of his valuable hours with us throughout the project.

We thank all the **Teaching and Non-Teaching staff** for their encouragement and support in successful completion of this project.

We are thankful to our Principal **Dr. S. Sambhu Prasad**, for providing facilities and continuous support to complete this project.

We thank the **Management of N S Raju Institute of Technology** for providing the various resources to complete this project.

21NU1A0416 B. V. SATYA ANAND

22NU5A0404 B. VAMSI REDDY

21NU1A0401 ABDUL AYESHA

21NU1A0442 G. ABHISHEK BABU

21NU1A0427 D. YASWANTH SAI

ABSTRACT

Underwater environments present unique challenges for communication, particularly for applications like obstacle avoidance and tracking marine life. Traditional wireless communication methods, such as Wi-Fi which relies on radio frequency (RF) waves, are severely limited due to the significant absorption of these waves by water. This absorption increases with depth, rendering long-range RF communication impractical. While various wired and wireless communication mediums exist, the convenience offered by wireless technologies has revolutionized terrestrial communication, as seen with ubiquitous protocols like RF, Zigbee, and Bluetooth in cellular phones and other gadgets. However, these RF-based protocols are ineffective underwater. In contrast, light possesses the capability to penetrate and travel through water, albeit with some attenuation depending on water clarity and depth. Li-Fi (Light Fidelity) technology, which utilizes light for data transmission, emerges as a viable alternative for underwater communication. This project, titled "LI-FI based underwater communication using Arduino," aims to explore and implement a cost-effective underwater communication system. By leveraging the light communication capabilities of Li-Fi and the accessibility of the Arduino platform, this project will investigate the feasibility of short-range data transmission underwater. The system will be designed to demonstrate the basic principles of Li-Fi communication in an aquatic environment, potentially paving the way for future applications in underwater sensing, robotics, and environmental monitoring using readily available and affordable hardware. The project will focus on the hardware implementation using Arduino to control light modulation for data encoding and the detection of light signals for data retrieval, providing a foundational understanding of Li-Fi's potential in overcoming the limitations of traditional underwater communication methods.

Keywords: Light Fidelity(LI-FI), Underwater Optical Communication, Visible Light Communication (VLC), LED-based Communication, Photodiode Receiver, High-Speed Data Transmission, Short-Range Wireless Communication, Signal Attenuation, Underwater Wireless Sensor Networks (UWSNs), Optical Wireless Communication (OWC), Data Modulation, Line-of-Sight Communication, Beam Collimation, Water Turbidity, Secure Communication, Low Latency Communication, Autonomous Underwater Vehicles (AUVs), Marine Technology.

LIST OF FIGURES

LIST OF TABLES

CONTENTS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

INSTITUTE

VISION

To promote societal empowerment and become an institution of excellence in the field of engineering education and research.

MISSION

1. To develop the students into outstanding professionals through innovative Teaching-Learning process.
2. To uphold research through long term Academia-Industry interaction.
3. To inculcate ethical standards and moral values.

DEPARTMENT

VISION

To become recognized forerunner in Electronics and Communication Engineering by producing competent and responsible graduates.

MISSION

1. To prepare technically competent graduates by establishing a conducive learner centric academic environment that uses innovative teaching learning processes.

2. To create research interests in the graduates by bringing in real-time engineering challenges through industry collaborations.

3. To make the graduates socially responsible citizens who provide sustainable solutions maintaining ethical and professional standards.

PROGRAM EDUCATIONAL OBJECTIVES

PEO 1: Our graduates will solve real-world problems of the 21^{st} Century in Electronics and Communication Engineering with satisfactory professional growth and required skills.

PEO 2: Our graduates will be able to pursue higher studies and engage in lifelong learning to adapt to evolving technologies and career demands.

PEO 3: Our graduates will demonstrate ethical behavior and social responsibility in their professional work.

List of Program Outcomes

As Per the Program of Study

PO1: Apply the knowledge of basic sciences and fundamental engineering concepts in solving engineering problems (**Engineering Knowledge**)

PO2: **I**dentify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. (**Problem Analysis**)

PO3: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. (**Design/Development of Solutions**)

PO4: Perform investigations, design and conduct experiments, analyze and interpret the results to provide valid conclusions **(Investigation of Complex Problems)**

PO5: Select/develop and apply appropriate techniques and IT tools for the design & analysis of the systems (**Modern Tool Usage**)

PO6: Give reasoning and assess societal, health, legal and cultural issues with competency in professional engineering practices **(The Engineer and Society)**

PO7: Demonstrate professional skills and contextual reasoning to assess environmental/societal issues for sustainable development (**The Environment and Sustainability)**

PO8: Demonstrate Knowledge of professional and ethical practices **(Ethics)**

PO9: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary situations **(Individual and Team Work)**

PO10: Communicate effectively among engineering community, being able to comprehend and write effectively reports, presentation and give / receive clears instructions **(Communication)**

PO11: Demonstrate and apply engineering & management principles in their own / team projects in multidisciplinary environment **(Project Finance and Management)**

PO12: Recognize the need for, and have the ability to engage in independent and lifelong learning **(Life** Long Learning)

PSO1: To demonstrate the ability to design and develop complex systems in the areas of next generation Communication Systems, lot based Embedded Systems, Advanced Signal and Image Processing, latest Semiconductor technologies, RF and Power Systems.)

PSO2: To demonstrate the ability to solve complex Electronics and Communication Engineering problems using the latest hardware and software tools along with analytical skills to contribute to useful, frugal and eco-friendly solutions.

CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

Visible light communications (VLC) work by switching bulbs on and off within nano seconds which is too quickly to be noticed by the human eye. Although Li-Fi bulbs would have to be kept on to transmit data, the bulbs could be dimmed to the point that they were not visible to humans and yet still functional. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi. Direct line of sight isn't necessary for Li-Fi to transmit a signal; light reflected off the walls can achieve 70 Mbps Li-Fi has the advantage of being useful in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants without causing Electromagnetic-Interference Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum but whereas WiFi utilizes radio waves, Li-Fi uses visible light. Li- Fi has almost no limitations on capacity.

The visible light spectrum is 10,000 times larger than the entire radio frequency spectrum. Researchers have reached data rates of over 10 Gbps, which is more than 250 times faster than superfast broadband Li-Fi is expected to be ten times cheaper than Wi- Fi. Short range, low reliability and high installation costs are the potential downsides. Pure LI-FI demonstrated the first commercially available Li-Fi system, the Li-1st, at the 2014 Mobile World Congress in Barcelona. Bg-Fi is a Li-Fi system consisting of an application for a mobile device, and a simple consumer product, like an IoT (Internet of Things) device, with color sensor, microcontroller, and embedded software. Light from the mobile device display communicates to the color sensor on the consumer product, which converts the light into digital information. Light emitting diodes enable the consumer product to communicate synchronously with the mobile device.

1.1 CHALLENGES

Traditional underwater communication relies on two primary methods: acoustic waves and radio frequency (RF) signals. Acoustic Communication: Acoustic waves are the most commonly used communication method in underwater systems. While they can travel over long distances, they face several major drawbacks. The speed of sound in water varies depending on factors like temperature, salinity, and depth, causing significant challenges in signal accuracy. Additionally, acoustic signals are prone to interference from water currents, noise from surrounding environments, and the phenomenon known as multi-path propagation, where signals are reflected off various surfaces.

Radio Frequency Communication: RF communication in underwater environments is limited by the absorption and scattering of radio waves in water. The attenuation of RF signals increases significantly with depth, meaning that long-range communication is impractical with traditional RF methods. Radio waves also suffer from signal loss when passing through saltwater, which is highly conductive, leading to very short ranges and low data rates. Consequently, RF communication is not ideal for deep-sea exploration or real-time data transmission.

Both acoustic and RF systems have their own limitations in underwater communication, driving the need for alternative approaches. This is where Li-Fi technology offers a promising solution.

Li-Fi technology presents a paradigm shift in underwater communication, offering the potential to overcome the limitations of traditional acoustic and RF methods. While challenges related to range, water clarity, and line of sight need to be addressed through ongoing research and development, the advantages of high data rates, low latency, and enhanced security make Li-Fi a compelling alternative for a wide range of underwater applications, paving the way for more efficient and sophisticated deep-sea exploration and real-time data transmission.

1.2 PRINCIPLES OF LI-FI TECHNOLOGY

Li-Fi, or Light Fidelity, is an optical wireless communication technology that uses light waves to transmit data. The fundamental principle behind Li-Fi is the modulation of light signals (from LEDs or lasers) to encode digital data, which is then decoded by photodetectors or photodiodes. In contrast to traditional communication methods, Li-Fi operates in the visible light spectrum, and it can also make use of infrared and ultraviolet wavelengths.

In the context of underwater communication, Li-Fi systems use powerful LED light sources or lasers to transmit signals to underwater receivers. The light can be modulated at high speeds to carry large volumes of data. Underwater Li-Fi systems take advantage of the fact that light travels much better through water than radio waves or sound waves. For example, blue and green light, which have shorter wavelengths, can penetrate water more effectively than longer wavelengths, such as red light, making them suitable for underwater communication.

These systems can achieve high data transmission rates, as light can be modulated at much higher frequencies than RF or acoustic signals. Underwater Li-Fi communication can also support a wide range of applications, from oceanographic research to underwater robotics, and it can enable secure, real-time communication in environments where traditional communication methods fail.

1.3 ADVANTAGES

There are several compelling advantages to using Li-Fi-based systems for underwater communication:

High Data Transfer Rates: One of the most significant advantages of Li-Fi is its ability to provide extremely high data transfer speeds. Traditional underwater communication methods, such as acoustic or RF signals, suffer from slow data transmission rates, often limiting the amount of information that can be sent in a given time frame. Li-Fi, on the other hand, can offer data rates up to gigabits per second (Gbps), making it ideal for real-time communication in underwater environments, including streaming video feeds, high-resolution images, and large scientific datasets.

Lower Signal Attenuation: Light waves experience much less attenuation in water than radio waves or

sound waves, meaning that Li-Fi systems can transmit data over greater distances without significant loss of signal quality. This characteristic makes Li-Fi an excellent choice for deep-sea exploration or any underwater applications requiring long-range communication.

1.4 APPLICATION OF LI-FI

Recent studies have explored the application of Li-Fi in underwater communication systems, focusing on its potential to overcome the limitations of traditional acoustic and RF communication methods. The ability of visible light communication (VLC) to transmit data over distances in water has been extensively researched, with promising results. According to Liang et al. (2019), visible light, particularly in the blue and green wavelengths, experiences the least attenuation in water, making it ideal for underwater communication. The research has shown that Li-Fi can achieve data rates far exceeding those of traditional underwater communication methods, including gigabit-speed data transmission.

Li-Fi's ability to offer high-speed communication makes it highly suitable for applications that require the transmission of large amounts of data in real-time, such as video streaming and sensor data exchange. Autonomous underwater vehicles (AUVs), require high data rates to transmit real-time video feeds and sensor data to operators on the surface. Li-Fi provides a promising solution for these applications, where high bandwidth and low latency are critical. Similarly, for remote and environmental monitoring, where real-time communication and large data transfers are necessary, Li-Fi can play an essential role in enhancing the quality of communication and the speed at which data can be relayed.

1.5 EXISTING SYSTEM

The primary drawback of the existing communication systems that use radio signals in submarines is that radio waves are heavily attenuated when they pass through water. This attenuation limits the range and data rate of the communication system and makes it susceptible to interference from other radio sources. Additionally, radio signals can also be intercepted by unauthorized parties, posing a security risk to submarine operations. Therefore, in underwater environments, traditional radio communication is not a reliable method of communication and can compromise the safety and security of the submarine crew. In contrast, Li-Fi technology offers high data rates, low latency, and immunity to electromagnetic interference, making it a promising alternative to traditional radio communication in submarines.

1.6 PROPOSED SYSTEM

The proposed system is carried out using LI-FI technology. The LI-FI system has been connected to each vehicle. That li-fi system is used to transmit and receive information form a vehicle. Here, In this proposed system we have used various sensor like eye blink sensor, ultrasonic sensor, mems sensor and alcohol sensor. This sensor has been connected with a microcontroller to each vehicle. If the rider consumes alcohol then the alcohol sensor senses it and give that information to the nearest vehicle going in front of it through LI-FI. Because while drunk and driving the rider may ride with over speed and it may hit the other vehicles which results accidents. The rider should follow a particular distance with other vehicle.

When the vehicle really close to next vehicle then the ultrasonic sensor detects it and transmit that information through LI-FI. This will help to reduce the accidents. MEMS sensor senses axis of the car, when there is a tilt in axis, it will send message. This MEMS sensor will help to detect in case of rash driving. And that information will be shared with the help of Li-Fi technology. Here, we used one more sensor called eye blink sensor that detects the drowsiness of a rider which could alert the driver before mishap happens. We have connected an alarm system for that. Here we have used a liquid crystal display to monitor all these parameters. When the vehicle really close to next vehicle then the ultrasonic sensor detects it and transmit that information through LI-FI. This will help to reduce the accidents. MEMS sensor senses axis of the car, when there is a tilt in axis, it will send message. This MEMS sensor will help to detect in case of rash driving. This sensor has been connected with a microcontroller to each vehicle. If the rider consumes alcohol then the alcohol sensor senses it and give that information to the nearest vehicle going in front of it through LI-FI. This will help to reduce the accidents.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

1.“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."

2. “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."

3.Robert Codd-Downey and Michael Jenkin. “Wireless Teleoperation of an Underwater Robot using Li Fi”, 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 www.irjmets.com @International Research Journal of Modernization in Engineering, Technology and Science [1366] e-ISSN: 2582-5208 International Research Journal of Modernization in Engineering Technology and Science (Peer- Reviewed, Open Access, Fully

RefereedInternational Journal) Volume:06/Issue:04/April-2024 Impact Factor- 7.868 www.irjmets.com the stages of Li-Fi's development, the hurdles in its implementation, and its potential to revolutionize underwater exploration and bolster security measures."

4. "Chandrika V S, Praveen Balaji, Sakthi Ganesh D, Yaswin Krishna N", "A Li-Fi Based Wireless Optical Networking System for Distress Alarming in Fisherman Boats", 2022.

"In this paper, we develop a Li-Fi based visible light communication system to alert nearby coast guard or fellow fishermen during emergencies. The system integrates GPS and Li-Fi for precise location transmission, demonstrating Li-Fi's utility in maritime safety applications."

5. "Mohammad Vahid Jamali, Pooya Nabavi, Jawad A. Salehi", "MIMO Underwater Visible Light Communications", 2017.

"Our study explores a multiple-input multiple-output (MIMO) configuration for underwater visible light communication, addressing challenges such as inter-symbol interference and channel fading. We propose a detection technique that significantly enhances bit error rate (BER) performance, reinforcing Li-Fi's feasibility for high-speed underwater links."

6. "Dong-Chang Li, Chia-Chun Chen, Shien-Kuei Liaw, Shofuro Afifah, Jiun-Yu Sung, Chien-Hung Yeh", "Performance Evaluation of Underwater Wireless Optical Communication System", 2021.

"We examine the impact of various environmental parameters such as turbidity and salinity on the efficiency of underwater optical wireless communication. Our findings guide the design of robust Li-Fi systems capable of adapting to fluctuating underwater conditions."

7. "Tianyu Wang, Hongyu Zhang, Zhaocheng Wang", "Underwater Optical Wireless Communications: Overview", 2020.

"This overview highlights the state-of-the-art technologies in underwater optical communication, particularly focusing on blue-green laser sources. The paper evaluates Li-Fi's advantages in latency, security, and bandwidth over acoustic and RF systems. We propose a detetion technique that significantly enhances bit error rate and performance of Li-Fi system."

8. "N. R. Krishnamoorthy, Ajit Gerald, G. Rajalakshmi, D. Marshiana, T. Thaj Mary Delsy", "An Automated Underwater Wireless Communication System Using Li-Fi", 2021.

"In this research, we present an automated underwater communication module utilizing Li-Fi, integrated with IoT and GPS. The solution enhances real-time data sharing among underwater units, showcasing Li-Fi's compatibility with modern smart maritime systems."

9. "Nasir Saeed, Abdulkadir Celik, Tareq Y. Al-Naffouri, Mohamed-Slim Alouini", "Underwater Optical Wireless Communications, Networking, and Localization: A Survey", 2018.

"This comprehensive survey addresses the multifaceted challenges and progress in underwater optical wireless communication. It evaluates physical layer constraints and proposes solutions for localization and network routing using Li-Fi technologies."

10. "Feng Wang, Yifan Liu, Fei Jiang, Nan Chi", "High-Speed Underwater Optical Wireless Communication with Advanced Signal Processing", 2022.

"We provide a detailed analysis of signal processing techniques such as OFDM and adaptive equalization to boost the speed and reliability of underwater Li-Fi links. Our study serves as a roadmap for optimizing system efficiency in complex underwater environments."

11. "Abdulkadir Celik, Nasir Saeed, Basem Shihada, Tareq Y. Al-Naffouri, Mohamed-Slim Alouini", "End-to-End Performance Analysis of Underwater Optical Wireless Relaying", 2019.

"We analyze end-to-end performance in underwater Li-Fi networks under location uncertainty. Our results propose dynamic relaying techniques to improve network resilience, aiding in vehicle tracking and anti-hacking mechanisms."

12. "Yunlong Zhao, Peng Zou, Fang Hu, Nan Chi", "Real-Time Underwater Wireless Optical Communication System Using LEDs", 2023.

"This study presents a real-time communication prototype using LED-based Li-Fi for underwater applications. We demonstrate long-range communication up to several meters with low latency and consistent signal integrity, useful in AUV-to-AUV communication."

13. “Yunlong Zhao, Peng Zou, Fang Hu, Nan Chi”, “Designing an Adaptive Underwater Visible Light Communication System”, 2023.

"We explore an adaptive system for underwater visible light communication. The design incorporates real-time beam alignment and adaptive modulation, allowing uninterrupted data flow in mobile underwater networks."

14. “Chengyu Liu, Xiang He, Yadong Liu”, “Modeling and Simulation of Turbulence Effects in Underwater Optical Wireless Communication”, 2021.

"In this work, we simulate underwater turbulence and its effect on optical signal propagation. The study emphasizes Li-Fi’s capacity to mitigate signal degradation through adaptive channel modeling and compensation algorithms."

15. “G. Tuna, S. K. Goudos”, “Light Fidelity (Li-Fi) Applications in Underwater Communication”, 2020.

"Our paper reviews key applications of Li-Fi in underwater contexts, from diver communication to underwater asset monitoring. We assess technical feasibility and hardware compatibility with existing underwater infrastructures."

16. “J. Huang, D. Li, H. Xu”, “Energy-Efficient Li-Fi-Based Underwater Communication for Surveillance Drones”, 2022.

"This research proposes an energy-efficient Li-Fi module designed for underwater drones engaged in surveillance missions. The paper focuses on power management and secure link establishment under dynamic water conditions."

17. “Ahmed Kadhim, Amir Taherkordi”, “Smart Lighting and Li-Fi Integration for Subaquatic IoT”, 2023.

"In our study, we merge smart lighting systems with Li-Fi for enhanced underwater IoT deployments. The integration enables dual-purpose lighting and communication, optimizing both power and bandwidth in aquatic sensor networks."

CHAPTER 3

HARDWARE ASPECTS

CHAPTER 3

HARDWARE ASPECTS

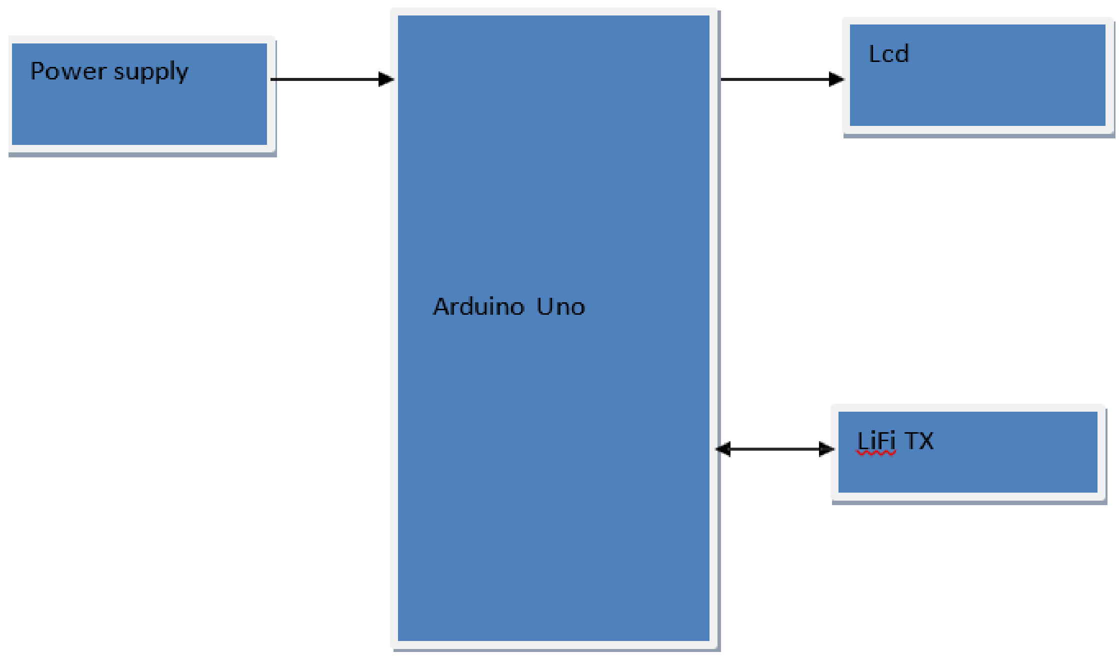

Fig 3.1: Block diagram of LI-FI Tx

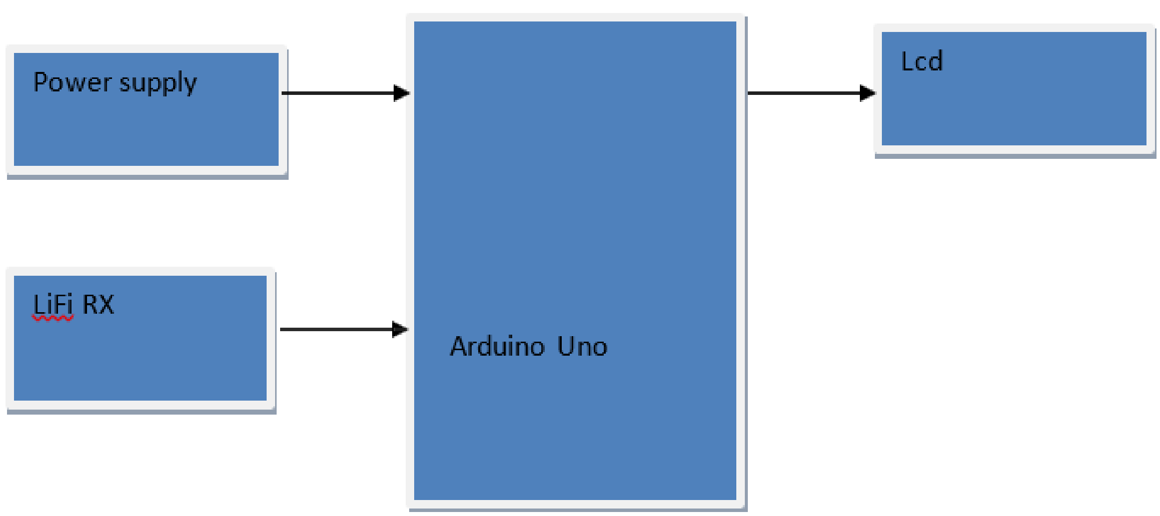

Fig 3.2: Block diagram of LI-FI Rx

3.1 POWER SUPPLY

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification.

Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage. Energy efficiency plays a significant role in underwater communication systems. Powering Li-Fi equipment using efficient, low-power consumption LEDs is one way to extend the operational life of the system, especially in remote underwater environments. The use of energy-efficient power supplies is critical, particularly for devices like Autonomous Underwater Vehicles (AUVs), which rely on limited battery power. Research into low-power solutions is necessary to prevent the depletion of power in underwater systems, enabling longer operational durations.

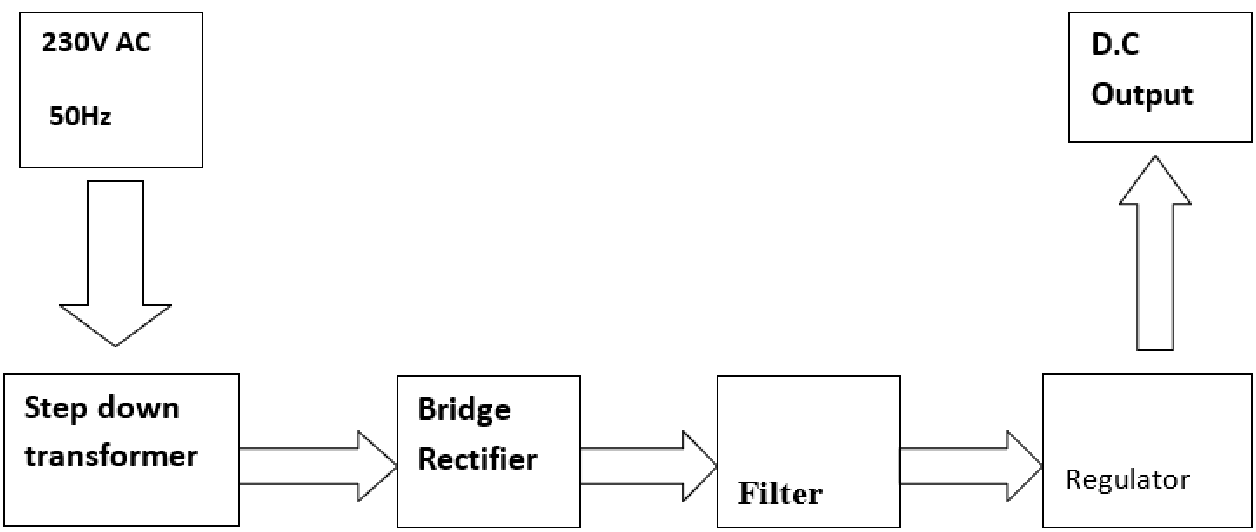

Fig 3.3: Block diagram of power supply

3.2 TRANSFORMER

Fig 3.4: Transformer

A transformer consists of two coils also called as “WINDINGS” namely PRIMARY & SECONDARY.

They are linked together through inductively coupled electrical conductors also called as CORE. A changing current in the primary causes a change in the Magnetic Field in the core & this in turn induces an alternating voltage in the secondary coil. If load is applied to the secondary then an alternating current will flow through the load. If we consider an ideal condition then all the energy from the primary circuit will be transferred to the secondary circuit through the magnetic field.

$$P_{primary} = P_{secondary}$$

$$I_p V_p = I_s V_s$$

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

3.3 Rectifier

A rectifier is a device that converts an AC signal into DC signal. For rectification purpose we use a diode, a diode is a device that allows current to pass only in one direction i.e. when the anode of the diode is positive with respect to the cathode also called as forward biased condition & blocks current in the reversed biased condition to use both the half cycles of the AC signal. This can be achieved by using a center tapped transformer i.e. we would have to double the size of secondary winding & provide connection to the center. So during the positive half cycle diode D1 conducts & D2 is in reverse biased condition. During the negative half cycle diode D2 conducts & D1 is reverse biased. Thus we get both the half cycles across the load.

One of the disadvantages of Full Wave Rectifier design is the necessity of using a center tapped transformer, thus increasing the size & cost of the circuit. This can be avoided by using the Full Wave Bridge Rectifier.

3.4 Filter Capacitor

Even though half wave & full wave rectifier give DC output, none of them provides a constant output voltage. For this we require to smoothen the waveform received from the rectifier. This can be done by using a capacitor at the output of the rectifier this capacitor is also called as “FILTER CAPACITOR” or “SMOOTHING CAPACITOR” or “RESERVOIR CAPACITOR”. Even after using this capacitor a small amount of ripple will remain. We place the Filter Capacitor at the output of the rectifier the capacitor will charge to the peak voltage during each half cycle then will discharge its stored energy slowly through the load while the rectified voltage drops to zero, thus trying to keep the voltage as constant as possible.

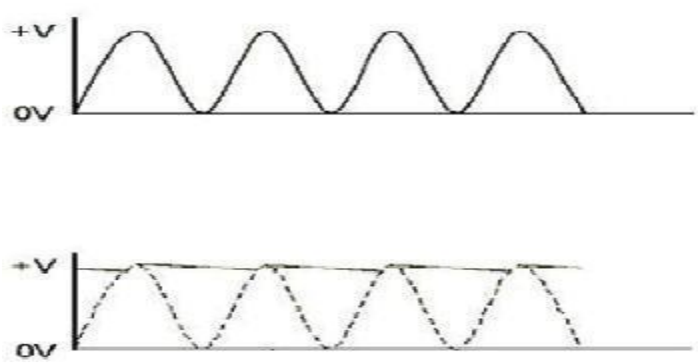

Fig 3.5: Waveforms of Filter Capacitor

If we go on increasing the value of the filter capacitor then the Ripple will decrease. But then the costing will increase. The value of the Filter capacitor depends on the current consumed by the circuit, the frequency of the waveform & the accepted ripple

where,

$$C = \frac{V_r F}{I}$$

Vr = accepted ripple voltage (should not be more than 10% of the voltage), I= current consumed by the circuit in Amperes.

F= frequency of the waveform. A half wave rectifier has only one peak in one cycle so F=25Hz

Whereas a full wave rectifier has Two peaks in one cycle so F=100Hz.

3.5 Voltage Regulator

A Voltage regulator is a device which converts varying input voltage into a constant regulated output voltage. Voltage regulator can be of two types

1. Linear Voltage Regulator

Also called as Resistive Voltage regulator because they dissipate the excessive voltage resistively as heat.

2. Switching Regulators.

They regulate the output voltage by switching the Current ON/OFF very rapidly. Since their output is either ON or OFF it dissipates very low power thus achieving higher efficiency as compared to linear voltage regulators. But they are more complex & generate high noise due to their switching action. For low level of output power switching regulators tend to be costly but for higher output wattage they are much cheaper than linear regulators.

The most commonly available Linear Positive Voltage Regulators are the 78XX series where the XX indicates the output voltage. And 79XX series is for Negative Voltage Regulators.

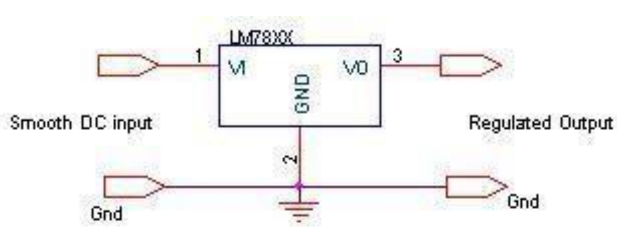

Fig 3.6: Pin diagram of Voltage regulator

After filtering the rectifier output the signal is given to a voltage regulator. The maximum input voltage that can be applied at the input is 35V.Normally there is a 2-3 Volts drop across the regulator so the input voltage should be at least 2-3 Volts higher than the output voltage. If the input voltage gets below the Vmin of the regulator due to the ripple voltage or due to any other reason the voltage regulator will not be able to produce the correct regulated voltage.

3.6 CIRCUIT DIAGRAM

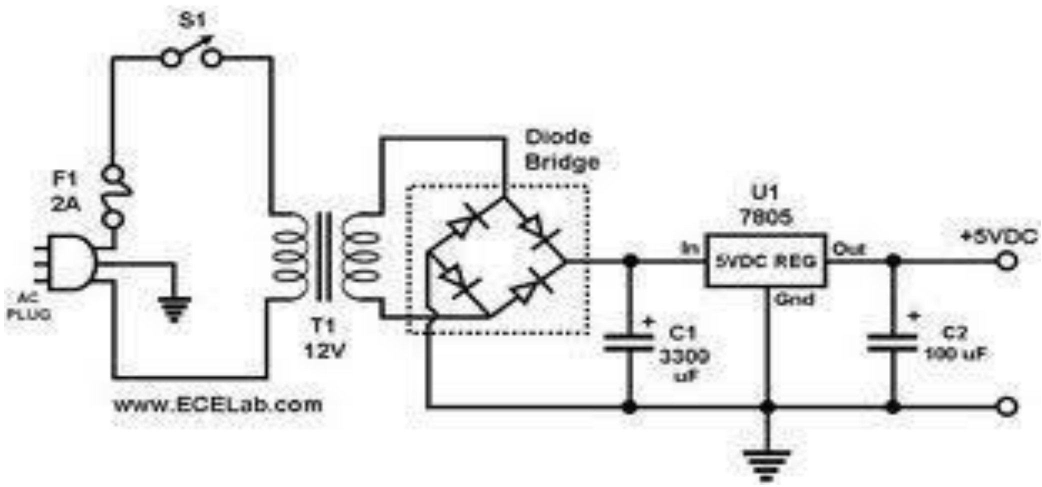

Fig 3.7: Circuit Diagram of power supply

- **IC 7805**

7805 is an integrated three-terminal positive fixed linear voltage regulator. It supports an input voltage of 10 volts to 35 volts and output voltage of 5 volts. It has a current rating of 1 amp although lower current models are available. Its output voltage is fixed at 5.0V. The 7805 also has a built-in current limiter as a safety feature. 7805 is manufactured by many companies, including National Semiconductors and Fairchild Semiconductors.The 7805 will automatically reduce output current if it gets too hot. The last two digits represent the voltage; for instance, the 7812 is a 12-volt regulator. The 78xx series of regulators is designed to work in complement with the 79xx series of negative voltage regulators in systems that provide both positive and negative regulated voltages, since the 78xx series can't regulate negative voltages in such a system.The 7805 & 78 is one of the most common and well-known of the 78xx series regulators, as it's small component count and medium-power regulated 5V make it useful for powering TTL devices.

Specifications of IC7805

Table 3.1: Specifications of IC7805

SPECIFICATIONS	IC 7805
V_{out}	**5V**
V_{ein} - V_{out} Difference	**5V - 20V**
Operation Ambient Temp	**0 - 125°C**
Output I_{max}	**1A**

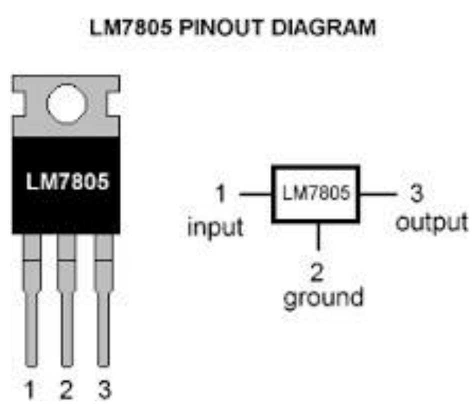

Fig 3.8: Pin diagram of 7805

- **IC7812**

Here is a 7812 voltage regulator circuit, but this is not a power supply with a 12V output voltage and load current 1A. IC LM7812 only serves as the input voltage of an LM723 regulator IC. So, these power supply circuits with a larger load current capability with a variable voltage at the maximum voltage of 6V.

Output voltage range of the 7812-voltage regulator circuit is 2.5V-6V with 6A- 8A load current.

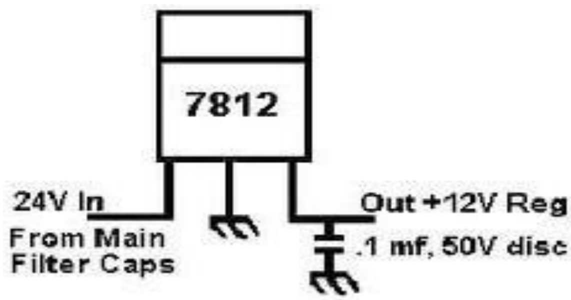

Fig 3.9: 7812 Pin Connection

3.7 ARDUINO UNO

Fig 3.10: Arduino UNO R3

The Arduino Uno R3 is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, 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. The Uno differs from all preceding boards in that it does not use the FTDI USB-to- serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Revision 3 of the board has the following new features:

- pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

The Arduino IDE serves as the central hub for interacting with Arduino microcontrollers. This user-friendly software provides a straightforward environment for writing code, known as sketches, in a simplified version of C++. Its intuitive interface features a text editor with helpful tools like syntax highlighting, making code creation easier. Beyond writing, the IDE handles the crucial steps of compiling your code into a format the Arduino can understand and then seamlessly uploads it to the connected board via a USB cable. Furthermore, it allows users to manage different Arduino board types and communication ports, and the integrated Library Manager greatly simplifies the inclusion of external code for expanded functionality.

The inclusion of a Serial Monitor facilitates debugging and data exchange, while the wealth of built-in examples provides a valuable starting point for new users. Available in both a stable legacy version and a more modern iteration with enhanced features, the free and open-source Arduino IDE empowers a global community of makers, educators, and engineers to bring their electronic projects to life.

3.8 Summary

Table 3.1: Table of Hardware

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Note: The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

3.9 Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

- **VIN:** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins

3.10 Memory

The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

3.11 Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digital Write(), and digital Read()functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms.

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt() function for details.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analog Write() function.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference() function. Additionally, some pins have specialized functionality:

- **TWI: A4 or SDA pin and A5 or SCL pin.** Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analog Reference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

3.12 Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer.

A Software Serial library allows for serial communication on any of the Uno's digital pins.

The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire l ibrary to simplify use of the I2C bus, see the documentation for details. For SPI communication, use the SPI library.

3.13 Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the **Tools > Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes preburned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader). See this user-contributed tutorial for more information.

3.14 Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of theATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

3.15 Li-Fi:

Introduction In the era of overcrowded (data communication) world, Li-Fi is a new way of wireless communication that uses LED lights to transmit data wirelessly. Transmission of data is one of the most important day to day activities in the fast growing world. The current wireless networks that connect us to the Internet are very slow when multiple devices are connected. Also with the increase in the number of devices which access the Internet, the availability of fixed bandwidth makes it much more difficult to enjoy high data transfer rates and to connect a secure network. Radio waves are just a small part of the electromagnetic spectrum available for data transfer. Li-Fi has got a much broader spectrum for transmission compared to conventional methods of wireless communications that rely on radio waves. The basic ideology behind this technology is that the data can be transferred through LED light by varying light intensities faster than the human eyes can perceive.

This technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible Spectrum, instead of Gigahertz radio waves for data transfer. The idea of Li-Fi was introduced for the first time by a German physicist Harald Hass in the TED (Technology, Entertainment, Design) Global talk on Visible Light Communication (VLC) in July 2011, by referring to it as “data through illumination”. He used a table lamp with an LED bulb to transmit a video of a blooming flower that was then projected onto a screen.

In simple terms, Li-Fi can be thought of as a light-based Wi-Fi i.e. instead of radio waves it uses light to transmit data. In place of Wi-Fi modems, Li- Fi would use transceivers fitted with LED lamps that could light a room as well as transmit and receive information. By adding new and unutilized bandwidth of visible light to the currently available radio waves for data transfer, Li-Fi can play a major role in relieving the heavy loads which the current wireless system is facing. Thus it may offer additional frequency band of the order of 400 THz compared to that available in RF communication which is about 300 GHz.

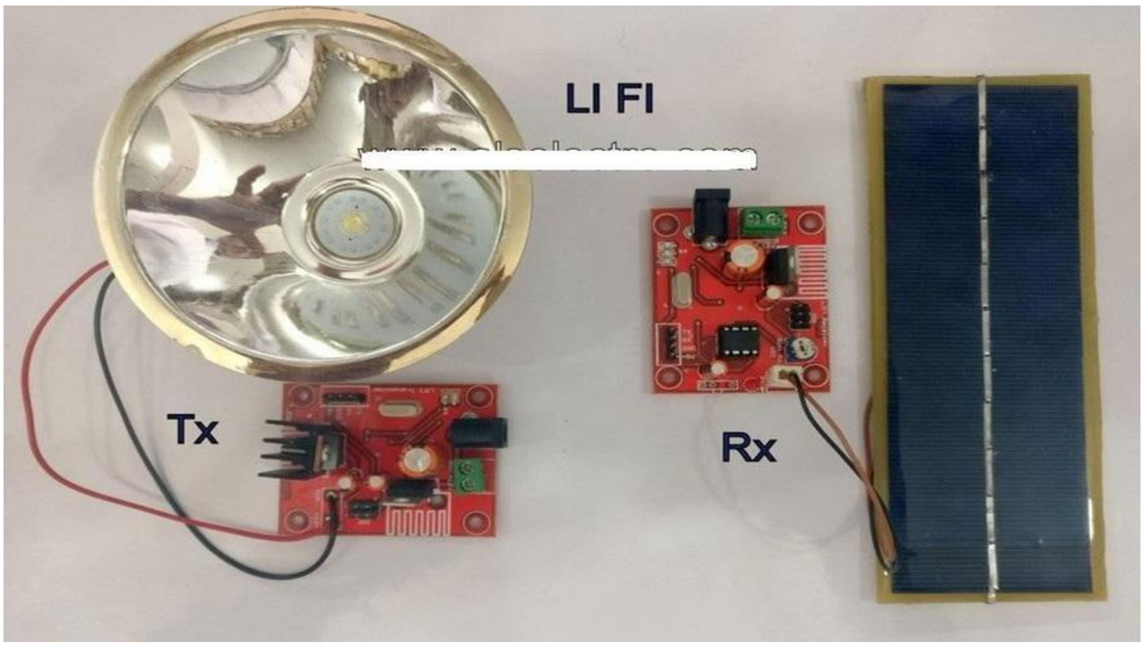

Fig 3.15: Li-Fi Setup

Also, as the Li-Fi uses the visible spectrum, it will help alleviate concerns that the electromagnetic waves coming with Wi-Fi could adversely affect our health. By Communication through visible light, Li-Fi technology has the possibility to change how we access the Internet, stream videos, receive emails and much more. Security would not be an issue as data can’t be accessed in the absence of light. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

3.16 Architecture of Li-Fi system

Li-Fi which can be the future of data communication appears to be a fast and cheap optical version of Wi-Fi. Being a Visible Light Communication (VLC), Li-Fi uses visible light of electromagnetic spectrum between 400 THz and 800 THz as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information in wireless medium. The main components of a basic

Li-Fi system may contain the following:

a) A high brightness white LED which acts as transmission source.

b) A silicon photodiode with good response to visible light as the receiving element. Switching the LEDs on and off can make them generate digital strings with different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. In this way, the LEDs work as a sender by modulating the light with the data signal. The LED output appears constant to the human because they are made to flicker at a phenomenal speed (millions of times per second) and it's impossible for human eye to detect this frequency. Communication rate more than 100 Mbps can be achieved by using high speed LEDs with the help of various multiplexing techniques. And this VLC data rate can be further increased to as high as 10 Gbps via parallel data transmission using an array of LED lights with each LED transmitting a different data stream. The Li-Fi transmitter system comprises of four primary subassemblies:

- Bulb
- RF Power AmpLi-Fier Circuit (PA)
- Printed Circuit Board (PCB)
- Enclosure

The Printed circuit board (PCB) controls the electrical inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. A Radio Frequency (RF) signal is generated by the Power AmpLi-Fier and is directed into the electric field of the bulb. As a result of the high concentration of energy in the electric field, the contents of the bulb will get vaporized into a plasma state at the bulb's centre. And this controlled plasma in turn will produce an intense source of light. All of these subassemblies are contained in an aluminium enclosure as shown in Fig. 2 above. Li-Fi Bulb sub-assembly: The bulb sub-assembly is the main part of the Li-Fi emitter. It consists of a sealed bulb embedded in a dielectric material which serves two purposes: one, it acts as a waveguide for the RF energy transmitted by the PA (Power AmpLi-Fier) and two, it acts as an electric field concentrator that focuses the energy into the bulb. The collected energy from the electric field rapidly heats the material in the bulb to a plasma state that emits light of high intensity of Visible light spectrum. Figure 3 shows the sub-assembly of the bulb. There are various inherent advantages of this approach which includes high brightness, excellent colour quality and high luminous efficacy of the emitter – in the range of 150 lumens per watt or greater.

The structure is mechanically robust without typical degradation and failure mechanisms associated with tungsten electrodes and glass to metal seals, resulting in useful lamp life of 30,000+ hours. In addition, the unique combination of high temperature plasma and digitally controlled solid state electronics results in an economically produced family of lamps scalable in packages from 3,000 to over 100,000 lumens. 4 Important factors that should be considered while designing Li- Fi are as follows:

1) Presence of Light

2) Line of Sight (Los)

3) for better performance use fluorescent light & LED

3.17 Working of Li-Fi

Basic Concept**:** Light Fidelity (Li-Fi) technology is a wireless communication system based on the use of visible light between the violet (800 THz) and red (400 THz). Unlike Wi-Fi which uses the radio part of the electromagnetic spectrum, Li-Fi uses the optical spectrum i.e. Visible light part of the electromagnetic spectrum. The principle of Li-Fi is based on sending data by amplitude modulation of the light source in a well-defined and standardized way. LEDs can be switched on and off faster than the human eyes can detect since the operating speed of LEDs is less than 1 microsecond. This invisible on-off activity enables data transmission using binary codes. If the LED is on, a digital ‘1’ is transmitted and if the LED is off, a digital ‘0’ is transmitted. Also these LEDs can be switched on and off very quickly which gives us a very nice opportunity for transmitting data through LED lights, because there are no interfering light frequencies like that of the radio frequencies in Wi-Fi. Li-Fi is thought to be 80% more efficient, which means it can reach speeds of up to 1Gbps and even beyond. Li-Fi differs from fibre optic because the Li-Fi protocol layers are suitable for wireless communication over short distances (up to 10 meters). 5 This puts Li-Fi in a unique position of extremely fast wireless communication over short distances.

How it Works**:** The working of Li-Fi is very simple. There is a light emitter on one end i.e. an LED transmitter, and a photo detector (light sensor) on the other. The data input to the LED transmitter is encoded in to the light (technically referred to as Visible Light Communication) by varying the flickering rate at which the LEDs flicker ‘on’ and ‘off’ to generate different strings of 1s and 0s. The onoff activity of the LED transmitter which seems to be invisible (The LED intensity is modulated rapidly that human eye cannot notice, so the light of the LED appears constant to humans), enables data transmission in light form in accordance with the incoming binary codes: switching ON a LED is a logical '1', switching it

OFF is a logical '0'. By varying the rate at which the LEDs flicker on and off, information can be encoded in the light to different combinations of 1s and 0s. In a typical setup, the transmitter (LED) is connected to the data network (Internet through the modem) and the receiver (photo detector/light sensor) on the receiving end receives the data as light signal and decodes the information, which is then displayed on the device connected to the receiver. The receiver (photo detector) registers a binary ‘1’ when the transmitter (LED) is ON and a binary ‘0’ when the transmitter (LED) is OFF. Thus flashing the LED numerous times or using an array of LEDs (perhaps of a few different colours) will eventually provide data rates in the range of hundreds of Mbps. The Li-Fi working is explained in a block diagram. Hence all that is required, is some or an array of LEDs and a controller that controls/encodes data into those LEDs. All one has to do is to vary the rate at which the LEDs flicker depending upon the data input to LEDs. Further data rate enhancements can be made in this method, by using array of the LEDs for parallel data transmission, or using mixtures of red , green and blue LEDs to alter the light’s frequency, with each frequency encoding a different data channel. Figure 7 shows working/deployment of a Li-Fi system connecting the devices in a room. enhancements can be made in this method, by using array of the LEDs for parallel data transmission, or using mixtures of red , green and blue LEDs to alter the light’s frequency, with each frequency encoding a different data channel. Figure 7 shows working/deployment of a Li-Fi system connecting the devices in a room.

Why Visible Light Communication**:** 7 The frequency spectrum that is available to us in the atmosphere consists of many wave regions like X-rays, gamma rays, u-v region, infrared region, visible light rays, radio waves, etc. Any one of the above waves can be used in the upcoming communication technologies but why the Visible Light part is chosen? The reason behind this is the easy availability and lesser harmful effects that occur due to these rays of light. VLC uses the visible light between 400 THz (780 nm) and 800 THz (375 nm) as medium which are less dangerous for high-power applications and also humans can easily perceive it and protect themselves from the harmful effects whereas the other wave regions have following. All one has to do is to vary the rate at which the LEDs flicker depending upon the data input to LEDs. Further data rate enhancements can be made in this method, by using array of the LEDs for parallel data transmission, or using mixtures of red , green and blue LEDs to alter the light’s frequency, with each frequency encoding a different data channel.

3.18 Disadvantages:

1. Radio waves are expensive (due to spectrum charges) and less secure (due to interference and possible interception etc.)
2. Gamma rays are harmful because it could be dangerous dealing with it, by the human beings due to their proven adverse effects on human health.
3. X-rays have health issues, similar to the Gamma Rays.
4. Ultraviolet light can be considered for communication technology purposes at place without people, otherwise they can also be dangerous for the human body when exposed continuously.

3.19 LCD:

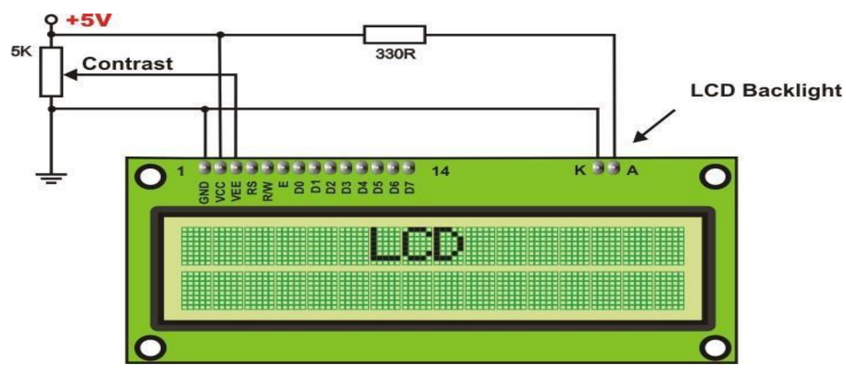

Fig 3.12: LCD

3.20 Pins Functions

There are pins along one side of the small printed board used for connection to the microcontroller. There are total of 14 pins marked with numbers (16 in case the background light is built in). The printed circuit board (PCB) used to connect to a microcontroller typically includes multiple pins, each assigned to specific tasks such as data transmission, power delivery, control signals, or other specialized functions. These pins may vary slightly depending on the board's design, but typically, for a standard 14-pin (or 16-pin with background light built-in) configuration, the functions are clearly outlined for ease of integration with microcontroller systems. These pins and their associated functions provide the necessary hardware interfaces for a microcontroller-based system, allowing it to communicate with external components, sensors, and actuators. Their function is described in the table

Table 3.3: Pin Functions

Function	Pin Number	Name	Logic State	Description
Ground	1	Vss	-	**0V**
Power supply	2	Vdd	-	**+5V**
Contrast	3	Vee	-	**0 – Vdd**
Control of	4	RS	0	**D0 – D7 are interpreted as**
operating			1	**commands**
				D0 – D7 are interpreted as
				data
	5	R/W	0	**Write data (from controller**
			1	**to LCD)**
				Read data (from LCD to
				controller)
	6	E	0	**Access to LCD disabled**
			1	**Normal operating**
			From 1	**Data/commands are**
			to 0	**transferred to LCD**
Data / commands	7	D0	0/1	**Bit 0 LSB**
	8	D1	0/1	**Bit 1**
	9	D2	0/1	**Bit 2**
	10	D3	0/1	**Bit 3**
	11	D4	0/1	**Bit 4**
	12	D5	0/1	**Bit 5**
	13	D6	0/1	**Bit 6**
	14	**D7**	**0/1**	**Bit 7 MSB**

3.21 Algorithm to send data to LCD

1. Make R/W low
2. Make RS=0;if data byte is command
3. RS=1;if data byte is data (ASCII value)
4. Place data byte on data register
5. Pulse E (HIGH to LOW)
6. Repeat the steps to send another data byte

3.22 LCD Initialization

This is the pit fall for beginners. Proper working of LCD depend on the how the LCD is initialized. We have to send few command bytes to initialize the LCD.

Simple steps to initialize the LCD:

1. Specify function set: Send 38H for 8-bit,double line and 5x7 dot character format.
2. Display On-Off control: Send 0FH for display and blink cursor on.
3. Entry mode set: Send 06H for cursor in increment position and shift is invisible.
4. Clear display: Send 01H to clear display and return cursor to home position.

Table 3.4: Addresses of cursor position for 16x2 HD44780

line 1	80 H	81 H	82 H	83 H	84 H	85 H	86 H	87 H	88 H	89 H	8A H	8B H	8C H	8D H	8E H	8F H
line 2	C0 H	C1 H	C2 H	C3 H	C4 H	C5 H	C6 H	C7 H	C8 H	C9 H	CA H	CB H	CC H	CD H	CE H	CF H

There are pins along one side of the small printed board used for connection to the microcontroller. There are total of 14 pins marked with numbers (16 in case the background light is built in). The printed circuit board (PCB) used to connect to a microcontroller typically includes multiple pins, each assigned to specific tasks such as data transmission, power delivery, control signals, or other specialized functions. These pins may vary slightly depending on the board's design, but typically, for a standard 14-pin (or 16-pin with background light built-in) configuration, the functions are clearly outlined for ease of integration with microcontroller systems.

CHAPTER 4

SOFTWARE DEVELOPMENT

CHAPTER 4

SOFTWARE DEVELOPMENT

4.1 INTRODUCTION

This tutorial will walk you through downloading, installing, and testing the Arduino software (also known as the Arduino IDE - short for Integrated Development Environment). Before you jump to the page for your operating system, make sure you've got all the right equipment.

What you will need:

- A computer (Windows, Mac, or Linux)
- An Arduino-compatible microcontroller (anything from this guide should work)
- A USB A-to-B cable, or another appropriate way to connect your Arduino- compatible microcontroller to your computer (check out this USB buying guide if you're not sure which cable to get).

Fig 4.1: An A-to-B USB Cable

If you're new to Arduino in general, you want to check out this tutorial to familiarize yourself with everyone's favorite microcontroller platform.

- What is an Arduino?

If you're ready to get started, click on the link in the column on the left that matches up with your operating system, or you can jump to your operating system here.

- Windows

- Mac
- Linux

4.2 WINDOWS

This page will show you how to install and test the Arduino software with a Windows operating system (Windows 8, Windows 7, Vista, and XP).

Windows 8, 7, Vista, and XP

- Go to the Arduino download page and download the latest version of the Arduino software for Windows.
- When the download is finished, un-zip it and open up the Arduino folder to confirm that yes, there are indeed some files and sub-folders inside. The file structure is important so don't be moving any files around unless you really know what you're doing.
- Power up your Arduino by connecting your Arduino board to your computer with a USB cable (or FTDI connector if you're using an Arduino pro). You should see the an LED labed 'ON' light up. (This diagram shows the placement of the power LED on the UNO).
- If you're running Windows 8, you'll need to disable driver signing, so go see the Windows 8 section. If you're running Windows 7, Vista, or XP, you'll need to install some drivers, so head to the Windows 7, Vista, and XP section down below.

4.3 Windows 8

Windows 8 comes with a nice little security 'feature' that 'protects' you from unsigned driver installation. Some older versions of Arduino Uno come with unsigned drivers, so in order to use your Uno, you'll have to tell Windows to disable driver signing. This issue has been addressed in newer releases of the Arduino IDE, but if you run into issues, you can try this fix first.

For a nice, step-by-step tutorial with pictures click here, otherwise the steps are outlined below

To *temporarily* disable driver signing:

- From the Metro Start Screen, open Settings (move your mouse to the bottom- right-corner of the screen and wait for the pop-out bar to appear, then click the Gear icon)
- Click 'More PC Settings'
- Click 'General'
- Scroll down, and click 'Restart now' under 'Advanced startup'.
- Wait a bit.

- Click ‘Troubleshoot’.
- Click ‘Advanced Options’
- Click ‘Windows Startup Settings’
- Click Restart.
- When your computer restarts, select ‘Disable driver signature enforcement‘ from the list.

To *permanently* disable driver signing (recommended, but has some minor security implications):

- Go to the metro start screen
- Type in “cmd”
- Right click “Command Prompt” and select “Run as Administrator” from the buttons on the bottom of your screen
- Type/paste in the following commands: bcdedit-set oadoptions DISABLE_INTEGRITY_CHECKS bcdedit -set TESTSIGNING ON
- Reboot!

4.4 Windows 7, Vista, and XP

Installing the Drivers for the Arduino Uno (from Arduino.cc)

Fig 4.2: Updating Drivers

- After a few moments, the process will fail, despite its best efforts
- Click on the Start Menu, and open up the Control Panel
- While in the Control Panel, navigate to System and Security. Next, click on System
- Once the System window is up, open the Device Manager
- Look under Ports (COM & LPT). You should see an open port named "Arduino UNO (COMxx)". If there is no COM & LPT section, look under 'Other Devices' for 'Unknown Device'
- Right click on the "Arduino UNO (COMxx)" or "Unknown Device" port and choose the "Update Driver Software" option

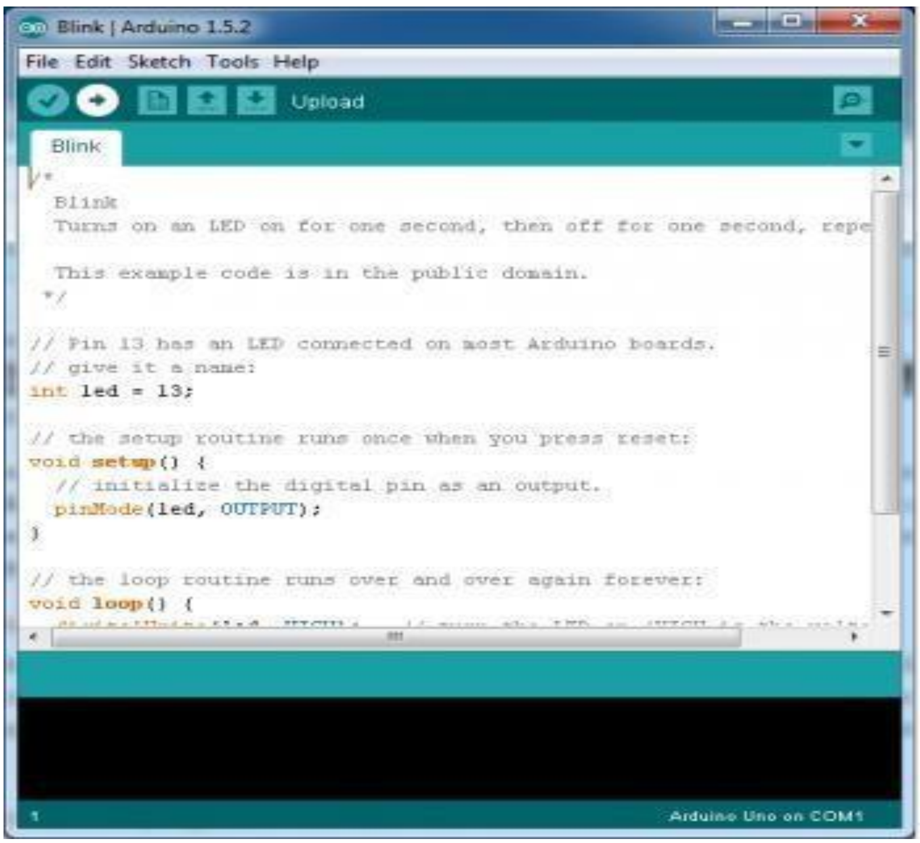

Fig 4.5: Blink LED Code (Sample)

- Next, choose the "Browse my computer for Driver software" option
- Finally, navigate to and select the Uno's driver file, named "ArduinoUNO.inf", located in the "Drivers" folder of the Arduino Software download (not the "FTDI USB Drivers" sub-directory). If you cannot see the .inf file, it is probably just hidden. You can select the 'drivers' folder with the 'search sub-folders' option selected instead.

- Windows will finish up the driver installation from there

For earlier versions of the Arduino boards (e.g.Arduino Duemilanove, Nano, or Diecimila) check out this page for specific directions.

Launch and Blink!

After following the appropriate steps for your software install, we are now ready to test your first program with your Arduino board!

- Launch the Arduino application
- If you disconnected your board, plug it back in
- Open the Blink example sketch by going to: File > Examples > 1.Basics > Blink
- Select the type of Arduino board you're using: Tools > Board > your board type
- Select the serial/COM port that your Arduino is attached to: Tools > Port > COMxx
- If you're not sure which serial device is your Arduino, take a look at the available ports, then unplug your Arduino and look again. The one that disappeared is your Arduino.

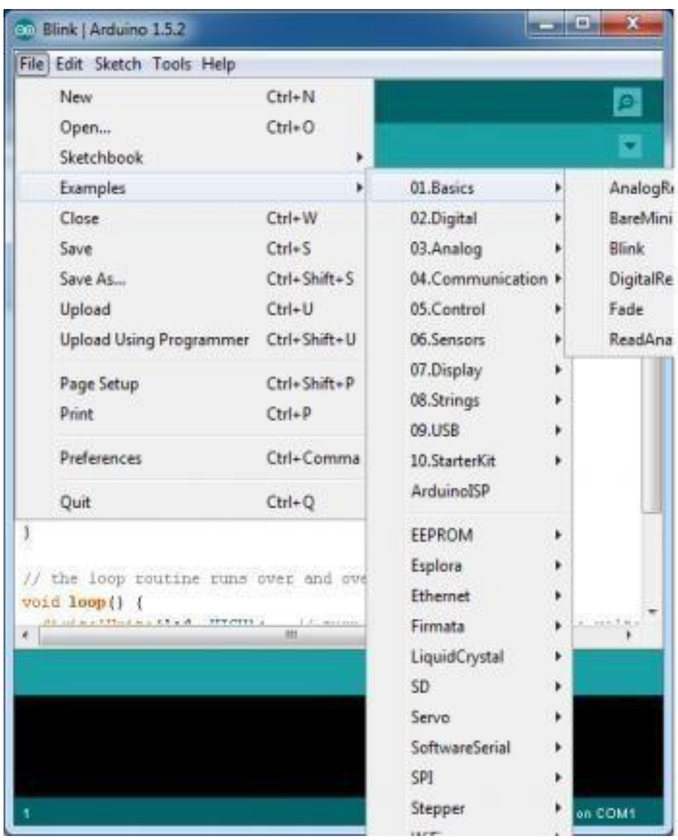

Fig 4.3: Example Codes

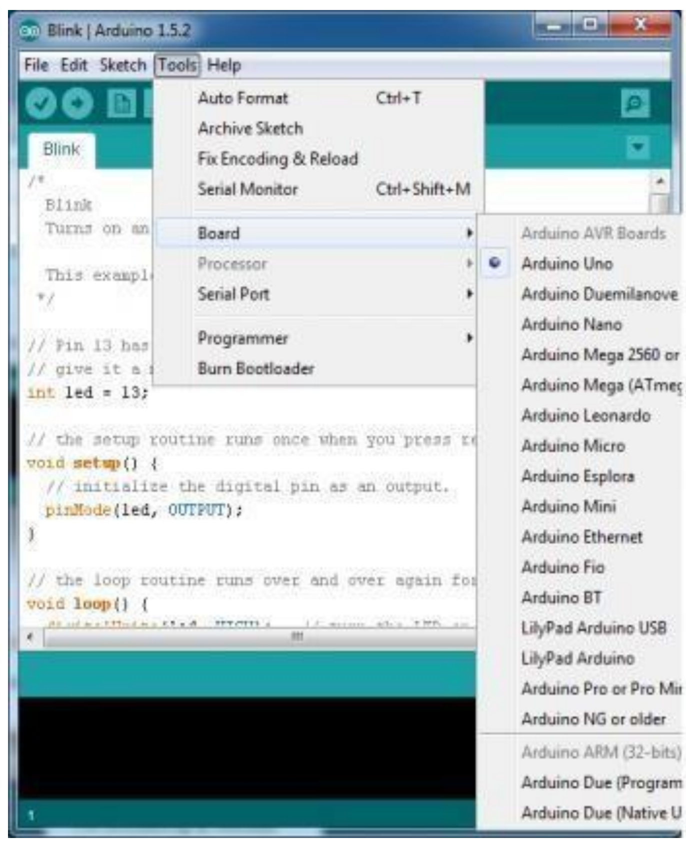

Fig 4.4: Selecting Board

- with your Arduino board connected, and the Blink sketch open, press the 'Upload' button
- After a second, you should see some LEDs flashing on your Arduino, followed by the message 'Done Uploading' in the status bar of the Blink sketch.
- If everything worked, the onboard LED on your Arduino should now be blinking! You just programmed your first Arduino!

4.5 MAC

This page will show you how to install and test the Arduino software on a Mac computer running OSX.

- Go to the Arduino download page and download the latest version of the Arduino software for Mac.

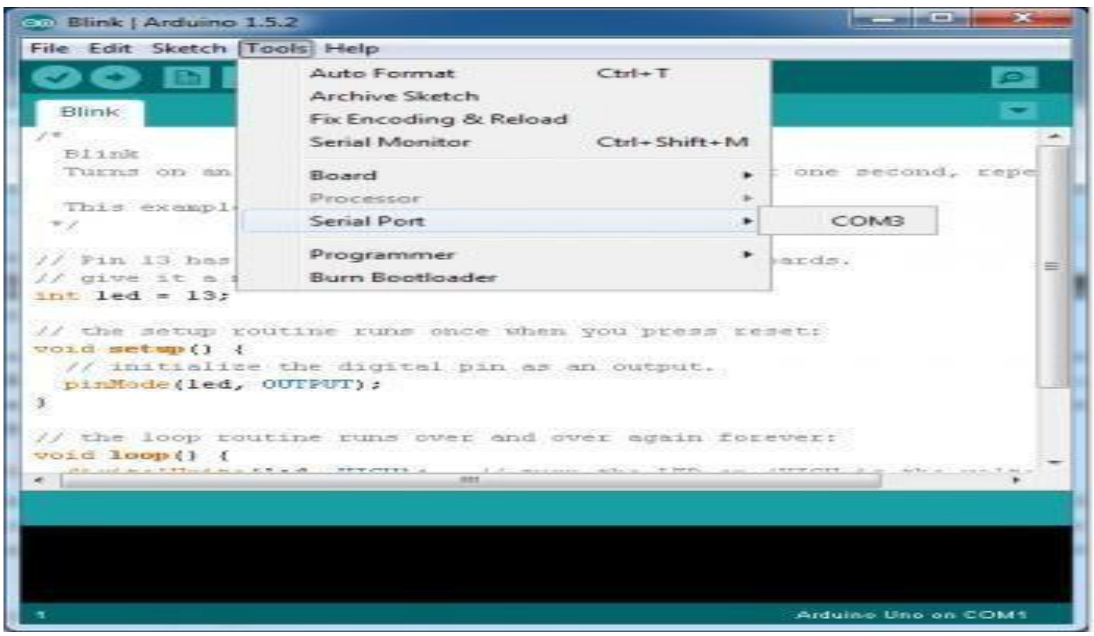

Fig 4.6: Selecting Serial Port

- When the download is finished, un-zip it and open up the Arduino folder to confirm that yes, there are indeed some files and sub-folders inside. The file structure is important so don't be moving any files around unless you really know what you're doing.
- Power up your Arduino by connecting your Arduino board to your computer with a USB cable (or FTDI connector if you're using an Arduino pro). You should see the LED labed 'ON' light up. (this diagram shows the placement of the power LED on the UNO).

4.6 FTDI DRIVERS

If you have an UNO, Mega2560, or Red board, you shouldn't need this step, so skip it!

- For other boards, you will need to install drivers for the FTDI chip on your Arduino.
- Go to the FTDI website and download the latest version of the drivers.
- Once you're done downloading, double click the package and follow the instructions from the installer.
- Restart your computer after installing the drivers.

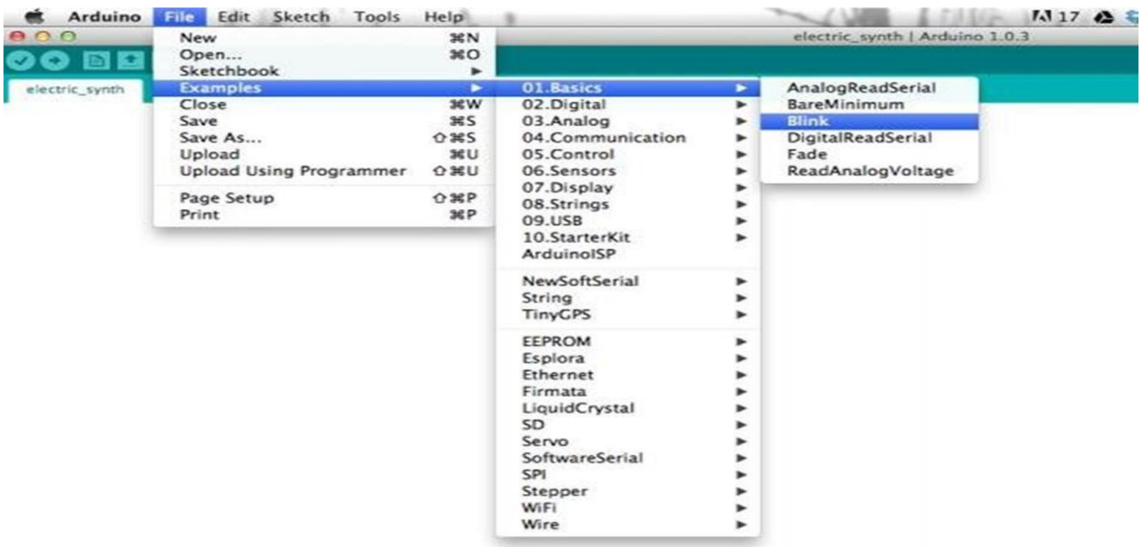

Fig 4.7: Examples in Mac

After following the appropriate steps for your software install, we are now ready to test your first program with your Arduino board.

- Launch the Arduino applicationIf you disconnected your board, plug it back in
- Open the Blink example sketch by going to: File > Examples > 1.Basics > Blink
- Select the type of Arduino board you're using: Tools > Board > your board type.
- Select the serial port that your Arduino is attached to: Tools > Port > xxxxxx (it'll probably look something like "/dev/tty.usbmodemfd131" or "/dev/tty.usbserial-131" but probably with a different number).
- If you're not sure which serial device is your Arduino, take a look at the available ports, then unplug your Arduino and look again. The one that disappeared is your Arduino.
- With your Arduino board connected and the Blink sketch open, press the 'Upload' button

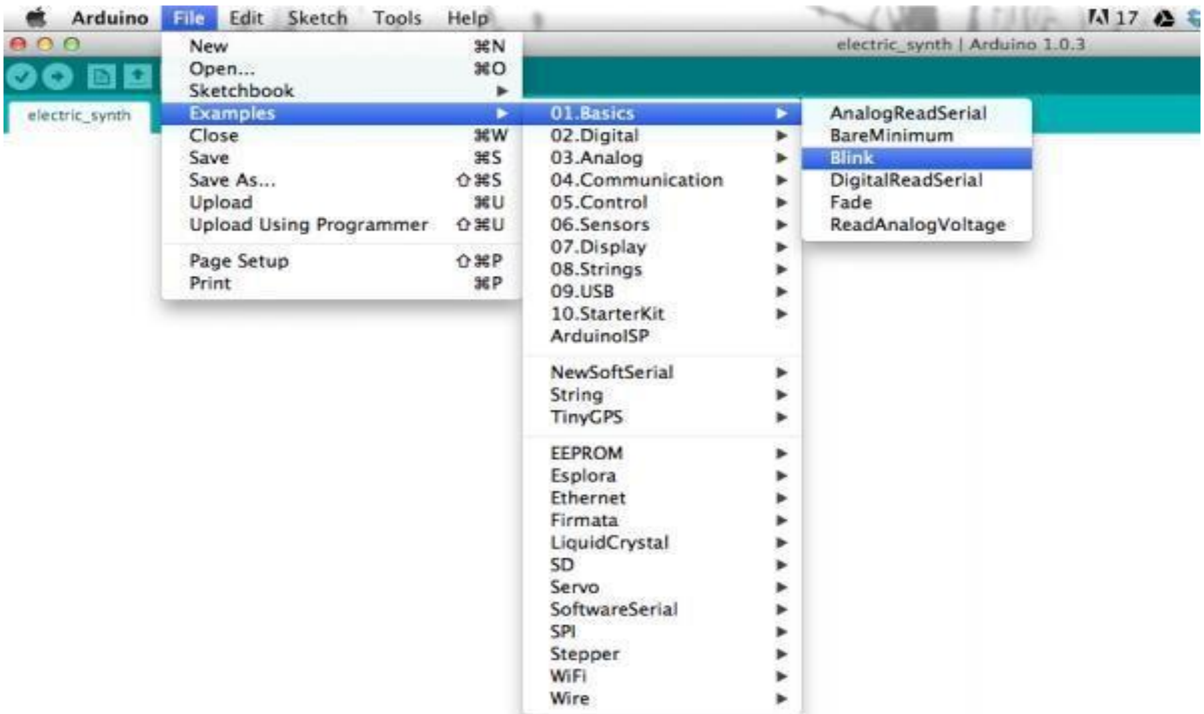

Fig 4.8: Example Codes in Mac

- After a second, you should see some LEDs flashing on your Arduino, followed by the message ‘Done Uploading’ in the status bar of the Blink sketch.

If everything worked, the onboard LED on your Arduino should now be blinking! You just programmed your first Arduino!

The fundamental "Blink" sketch in the Arduino IDE serves as an introductory example to controlling digital outputs. This basic program toggles an LED connected to a designated digital pin, commonly pin 13, on and off at a consistent rate. It utilizes the pinMode() function to configure the pin as an output, digitalWrite() to set the pin's state to HIGH (on) or LOW (off), and delay() to introduce pauses, measured in milliseconds, between state changes. This simple yet effective demonstration illustrates the core concepts of hardware interaction within the Arduino environment and highlights the essential structure of an Arduino sketch, featuring the setup() for initialization and the loop() for continuous execution. The "Blink" example is crucial for understanding how to manipulate digital signals and introduce timing into Arduino projects. By observing the LED's rhythmic flashing, beginners can grasp the direct relationship between the code and the physical behavior of a connected component.

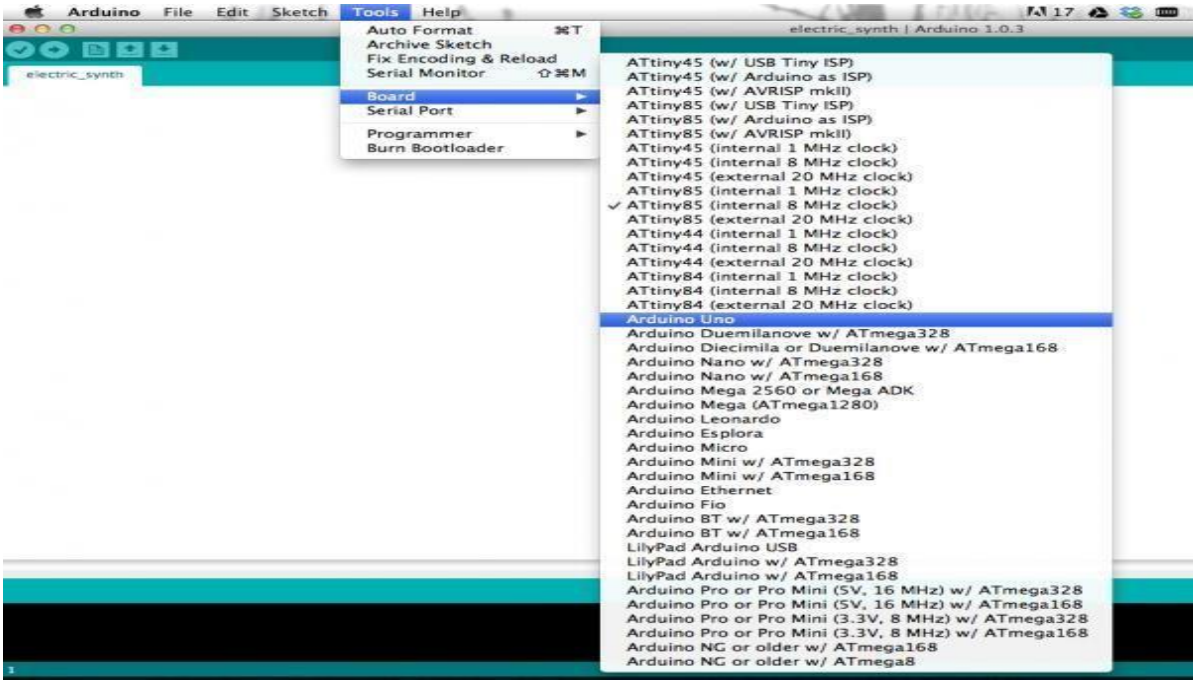

Fig 4.9: Board Selection in Mac

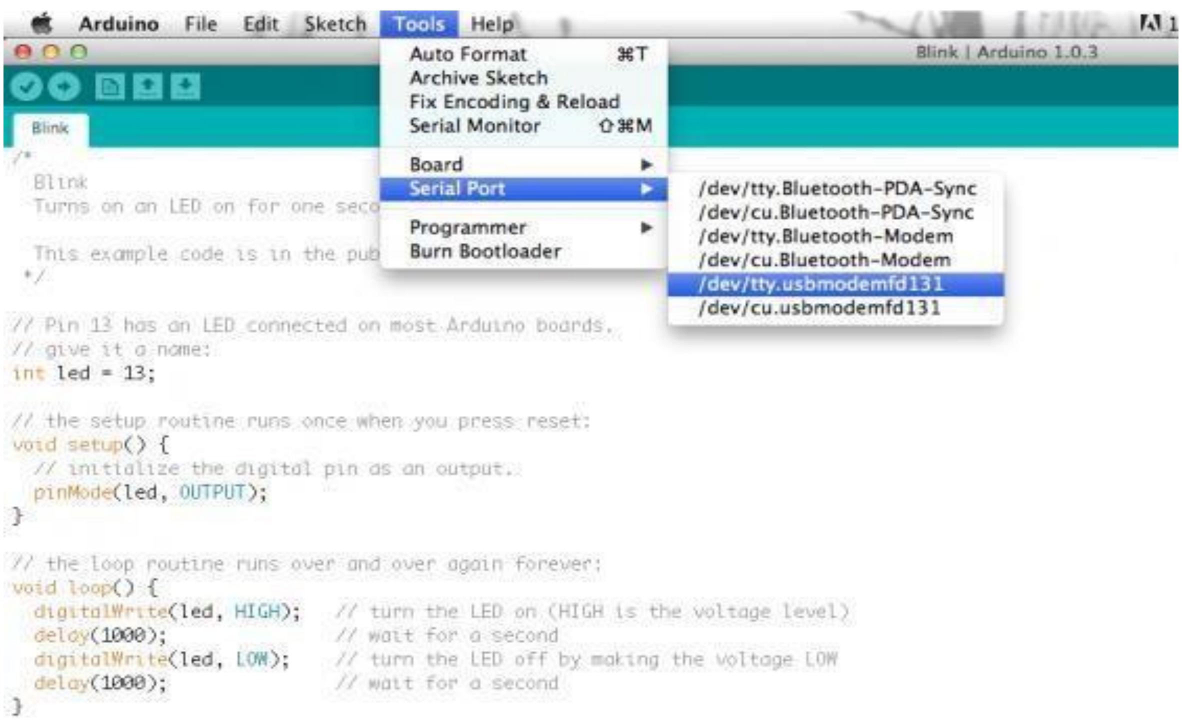

Fig 4.10: Serial Port selection in Mac

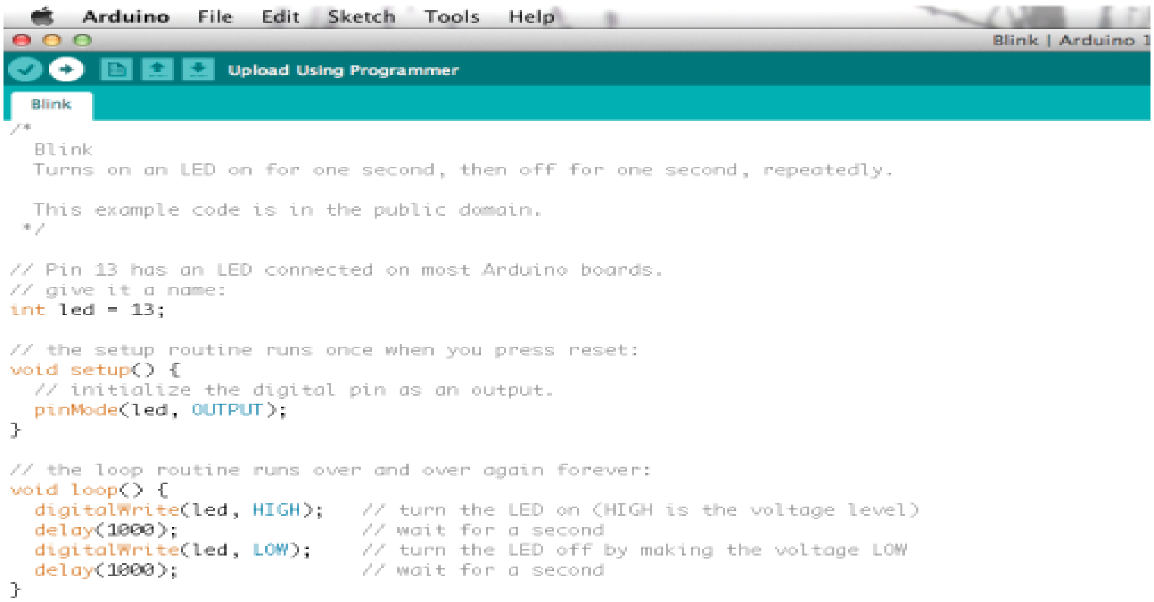

Fig 4.11: Blink Code in Mac

4.10 HACK AN ARDUINO

STEP1

Arduino microcontrollers come in a variety of types. The most common is the Arduino UNO, but there are specialized variations. Before you begin building, do a little research to figure out which version will be the most appropriate for your project.

STEP2

To begin, you'll need to install the Arduino Programmer, aka the integrated development environment (IDE).

STEP3

Connect your Arduino to the USB port of your computer. This may require a specific USB cable. Every Arduino has a different virtual serial-port address, so you 'll need to reconfigure the port if you're using different Arduinos.

STEP4

Set the board type and the serial port in the Arduino Programmer.

STEP5

Test the microcontroller by using one of the preloaded programs, called sketches, in the Arduino Programmer. Open one of the example sketches, and press the upload button to load it. The Arduino should begin responding to the program: If you've set it to blink an LED light, for example, the light should start blinking.

STEP6

To upload new code to the Arduino, either you'll need to have access to code you can paste into the programmer, or you'll have to write it yourself, using the Arduino programming language to create your own sketch. An Arduino sketch usually has five parts: a header describing the sketch and its author; a section defining variables; a setup routine that sets the initial conditions of variables and runs preliminary code; a loop routine, which is where you add the main code that will execute repeatedly until you stop running the sketch; and a section where you can list other functions that activate during the setup.

STEP7

once you've uploaded the new sketch to your Arduino, disconnect it from your computer and integrate it into your project as directed.

STEP8

Once the new sketch is successfully uploaded, the Arduino microcontroller will retain and execute this program independently. You can now disconnect the USB cable from your computer, and the Arduino will continue to run the uploaded sketch as long as it is powered.

STEP9

Integrate the programmed Arduino board into your specific project according to your design. This might involve connecting it to other electronic components, sensors, actuators, or a power source as required by your project's functionality. Ensure all connections are secure and correctly wired.

STEP10

Power up your complete project. The Arduino will now run the uploaded sketch, controlling the connected components and executing the intended behavior of your project. Observe and test the functionality to ensure it operates as expected.

These steps outline the initial process of working with an Arduino microcontroller. It begins with selecting the appropriate Arduino board and installing the necessary Arduino IDE software. Connecting the board to a computer and configuring the serial port are crucial for communication. Finally, the process involves testing the board with example sketches and then uploading custom code to control the Arduino for integration into a specific project. You can now disconnect the USB cable from your computer, and the Arduino will continue to run the uploaded sketch as long as it is powered.

CHAPTER 5

EXPERIMENTAL RESULT

The proposed Li-Fi based communication system for submarines uses an Arduino and water leak detector sensor to detect water leaks in the submarine. The Arduino is programmed to detect the presence of water using the water leak detector sensor. When the sensor detects water, it sends a signal to the Li-Fi transmitter. The Li-Fi transmitter then uses light to transmit the signal to the shore-side Li-Fi receiver. The Li-Fi transmitter uses an LED light source to transmit data.

The LED is modulated at a high frequency to encode the data. The modulated signal is then transmitted through the water using light. At the shore, the Li-Fi receiver captures the modulated signal and demodulates it to extract the data. The demodulated data is then displayed on the serial terminal. consumes alcohol, the alcohol sensor gives information to the nearest vehicle going in front of it through LI-FI transmitter. The eye blink sensor helps to detect the drowsy state of the driver. Here using above sensors when a distraction is notified through light fidelity technology, the light transmits to the receiver side where the photovoltaic cell receives the light photon

5.1 PROGRAM FORMATTING AND SYNTAX

Programs are entered line by line. Code is case sensitive which means “my variable” isdifferent than “My Variable”. Statements are any command. Statements are terminated with aSemicolon. A classic mistake is to forget the semicolon so if your program does not compile,examine the error text and see if you forgot to enter a colon.

Comments are any text that follows “//” on a line. For a multiline block comments, begin with “/*” and end with “*/” Constants are fixed number and can be entered as ordinary decimal numbers or in hexadecimal or in binary.

Labels are used to reference locations in your program. They can be any combination of letters, numbers and underscore (_), but the first character must be a letter. When used to mark a location, follow the label with a colon. When referring to an address label in an instructions line, don’t use the colon.

Power up your complete project. The Arduino will now run the uploaded sketch, controlling the connected components and executing the intended behavior of your project. Observe and test the functionality to ensure it operates as expected.

Here's an example

Repeat: digital Write (2, HIGH);Delay (1000);

Digital Write (2, LOW);Delay (1000);

Go to repeat;

Use labels sparingly as they can actually make a program difficult to follow and challenging to debug. In fact, some C programmers will tell you to never use labels. Variablesare allocated by declaring them in the program. Every variable must be declared. If a variableis declared outside the braces of a function, it can be seen everywhere in the program. It is declared inside the braces of a function; the variable can only be seen within that function.

Variables come in several flavors including byte 8bit, unsigned, 0 to 255, word 16bit,unsigned, o to 65,536, int 16bit, signed, 32,768 to 32,767, and long 32bit, signed, 2,147,483,648 to 2,147,483,647. Use byte variables unless you need negative numbers or numbers larger than 255, then use int variables. Using larger sizes than needed fills up preciousmemory space. Variable declarations generally appear at the top of the program.

Variable names can be any combinations of letters and numbers but must start with aletter. Names reserved for the programming instructions cannot be used for variable names and will give you an error message. Symbols are used to redefine how something is named and canbe handy for making the code more readable.

```
Void setup ()
{
pin mode (2, OUTPUT);
}
Void loop ()
{
digitalWrite (2, HIGH);delay (1000); digitalWrite (2.LOW);delay (1000);
}
```

This Arduino program initializes digital pin 2 as an output. In its main loop, it repeatedly turns the output pin HIGH (on) for one second and then LOW (off) for one second, effectively creating a blinking effect on a connected component like an LED.

5.2 PROGRAMMING STRUCTURE

All Arduino programs have two functions, setup () and loop (). The instructions you place in the startup () function are executed once when the program begins and are used to initialize Use it to set directions of pins or to initialize variables. The instructions placed in loopare executed repeatedly and from the main tasks of the program.

Therefore, every program has this structure.Void setup ()

```
{
// commands to initialize go here
}
Void loop ()
// commands to run your machine go here
}
```

The absolute, bareminimum, donothing program that can compile and run is

```
Void setup ()
{}
void loop ()
{}
```

The program performs no function, but is useful for clearing out any old program. Note that the compiler does not care about line returns, which is why this program works if typed allon one line.

5.3 COMMANDS

5.4 Pin Mode

This command, which goes in the setup () function, is used to set the direction of adigital I/O pin. Set the pin to OUTPUT if the pin is driving a LED, motor or other device.

Set the pin to INPUT if the pin is reading a switch or other sensor. On power up or reset, all pins default to inputs. This example sets pin 2 to an output and pin 3 to an input. Variables come in several flavors including byte 8bit, unsigned, 0 to 255, word 16bit,unsigned, o to 65,536, int 16bit, signed, 32,768 to 32,767, and long 32bit, signed, 2,147,483,648 to 2,147,483,647. Use byte variables unless you need negative numbers or numbers larger than 255, then use int variables.

```
Void setup ()
{
pin Mode (2, OUTPUT);pin Mode (3, INPUT);
}
```

5.5 Serial Print

The Serial Print command lets you see what's going on inside the Arduino from your computer. For example, you can see the result of math operation to determine if you are gettingthe right number. Or, you can see the state of a digital input pin to see if the Arduino is a sensor or switch properly. When your interface circuits or program does not seem to be working, use the Serial. Print command to shed a little light on the situation. For this command to show anything, you need to have the Arduino connected to the host computer with the USB cable. For the command to work, the command Serial.begin(9600) must be placed in the setup () function. After the program is uploaded, you must open the Serial Monitor window to use theresponse.

There are two forms of the print command. Serial.print() prints on the same line while Serial.println() starts the print on a new line.

Here is a brief program to check if your board is alive and connected to the PC.Void setup ()

```
{
Serial.begin(9600); Serial.println("Hello World");
}
Void loop ()
```

Here is a program that loops in place, displaying the value of an I/O pin. This is usefulfor checking the state of sensors or switches and to see if the Arduino is reading the sensor properly After uploading the program, use a jumper wire to alternately connect pin 2 to +5v and to Gnd.

```
Void setup ()
{
Serial.begin(9600);
}
Void loop ()
{
```

```
Serial.print(digitalRead (2));
Delay (100);
}
```

If you wanted to see the states of pins 2 and 3 at the same time, you can chain a few print commands, nothing that the last command is a println to start a new line.

5.6 EMBEDDED C

C is a high level programming language. Embedded C is just the extension variant of the C language. This programming language is hardware independent. On the other hand, embedded C language is truly hardware dependent.

5.7 Introduction

Embedded C extends the standard C programming language with specific features tailored for embedded systems development. These extensions aim to standardize the variations found in C implementations across different embedded platforms. Unlike general-purpose C, Embedded C often incorporates non-standard extensions to leverage the unique capabilities of microprocessors, such as fixed-point arithmetic for efficient numerical operations, mechanisms to manage multiple distinct memory banks crucial in resource-constrained environments, and direct support for basic input/output (I/O) operations to interact with hardware.

The C Standards Committee has actively worked towards providing a common standard for Embedded C implementations through Technical Reports. These standards define features not typically found in standard C, including the aforementioned fixed-point arithmetic, named address spaces for precise memory management, and standardized ways to address basic I/O hardware. Despite these extensions, Embedded C retains the core syntax and semantics of standard C, ensuring a familiar programming paradigm. Developers utilize fundamental C constructs like the main() function, variable definitions, data types, control flow statements (if-else, switch-case, loops), functions, data structures (arrays, strings, structures, unions), bitwise operations, and preprocessor macros.

However, it's important to recognize that Embedded C, while based on standard C, presents certain distinctions. These differences often arise from the specific requirements and constraints of embedded systems, such as limited memory, real-time processing needs, and direct hardware interaction. The subsequent sections of this project documentation will likely delve into these specific differences, highlighting how Embedded C is adapted and utilized.

Table 5.1: Data Types

S.No	Data types	Size in Bits	Data Range
1	Unsigned char	8bit	0255
2	Signed char	8bit	128 to +127
3	Unsigned int	16bit	0 to 65535
4	Signed int	16bit	32,768 to +32,767
5	Sbit	1bit	SFR bit addressable only
6	Bit	1bit	RAM bit addressable only

In embedded system programming C code is preferred over other language. Due to thefollowing reasons:

- Easy to understand
- High Reliability
- Portability
- Scalability

5.8 Embedded System Programming

Basic Declaration

Let's see the block diagram of Embedded C Programming development:

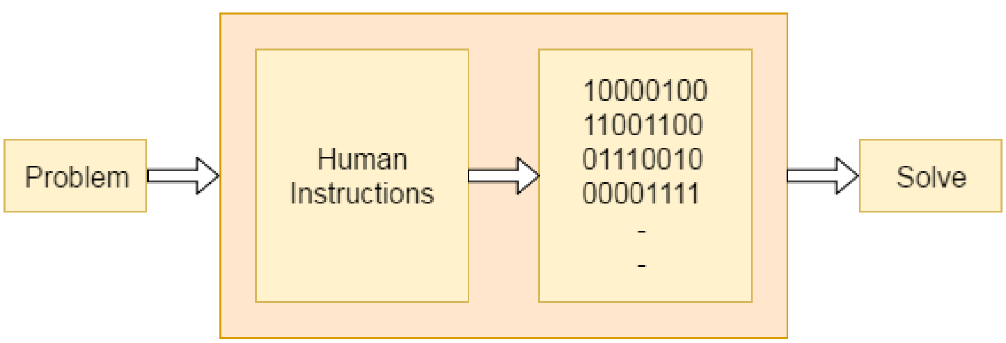

Fig 5.1: Block diagram of Embedded C development

Function is a collection of statements that is used for performing a specific task and a collection of one or more functions is called a programming language. Every language is consisting of basic elements and grammatical rules. The C language programming is designedfor function with variables, character set, data types, keywords, expression and so on are usedfor writing a C program.

5.9 Basic Embedded C Programming Steps

Let's see the block diagram representation of Embedded C Programming Steps:

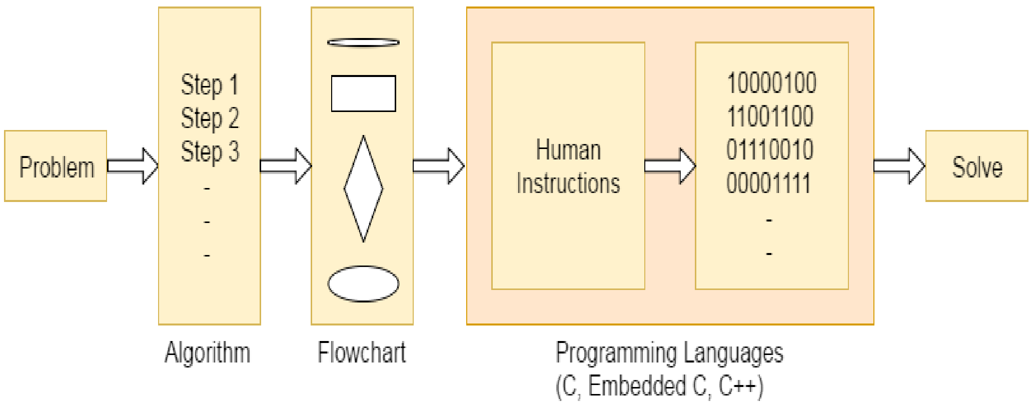

Fig 5.2: Block diagram of Embedded C programming steps

Embedded C programming involves a step-by-step process to develop software for microcontrollers and other embedded systems. The first step is to understand the hardware specifications and constraints of the target embedded system, including the microcontroller architecture, memory layout, and available peripherals. Once this understanding is established, the programmer moves on to designing the software architecture, defining the functionalities and tasks the embedded system will perform. Next, the actual coding phase begins, where the C programming language is used to write the software based on the predefined architecture. This involves implementing algorithms, con Figuring hardware peripherals, and managing memory efficiently.

The microcontroller programming is different for each type of operating system. Eventhough there are many operating system are exist such as Windows, Linux, RTOS, etc but RTOS has several advantage for embedded system development.

The subsequent sections of this project documentation will likely delve into these specific differences, highlighting how Embedded C is adapted and utilized within the context of the project's embedded hardware and software design. Understanding these nuances is crucial for effectively developing and deploying software on embedded targets.

CHAPTER 5

EXPERIMENTAL RESULT

5.10 HARDWARE KIT

5.11 Audio Transmission

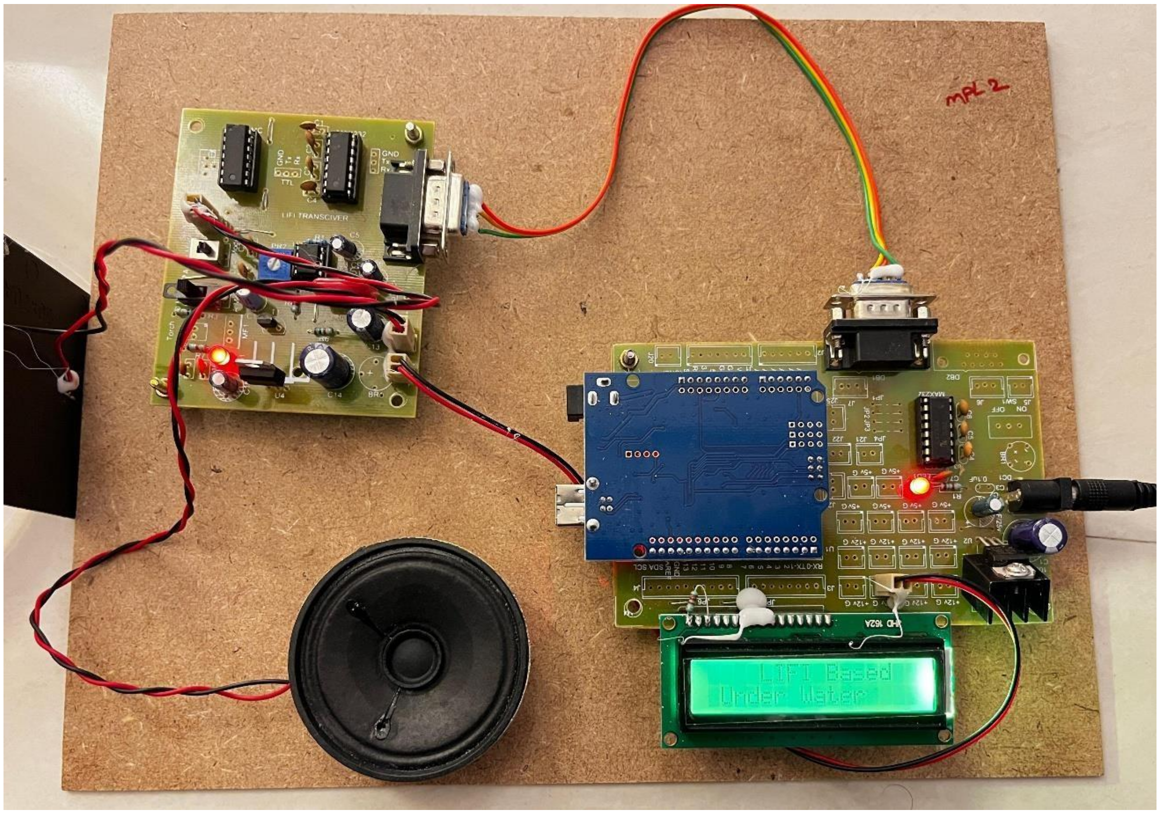

Fig 5.3: Audio Transmission

Implementing audio transmission in a Li-Fi project underwater involves converting sound waves into electrical signals using a microphone. These signals then modulate the intensity of a light source, such as an LED or laser, at a high frequency imperceptible to the human eye. This rapidly varying light, carrying the audio information, travels through the water. At the receiving end, a photodetector captures these light fluctuations and converts them back into electrical signals, which are then amplified and transformed back into audible sound waves using a speaker or headphones. This method leverages the faster speed of light compared to sound in water, potentially enabling clearer and quicker audio communication than traditional acoustic methods.

This light-based audio transmission offers a unique approach to underwater communication, potentially mitigating the distortions and limitations inherent in acoustic signaling over distance. The efficiency and range of this Li-Fi audio system would depend on factors like water clarity, light source intensity, and the sensitivity of the photodetector.

5.12 Data Transmission Underwater

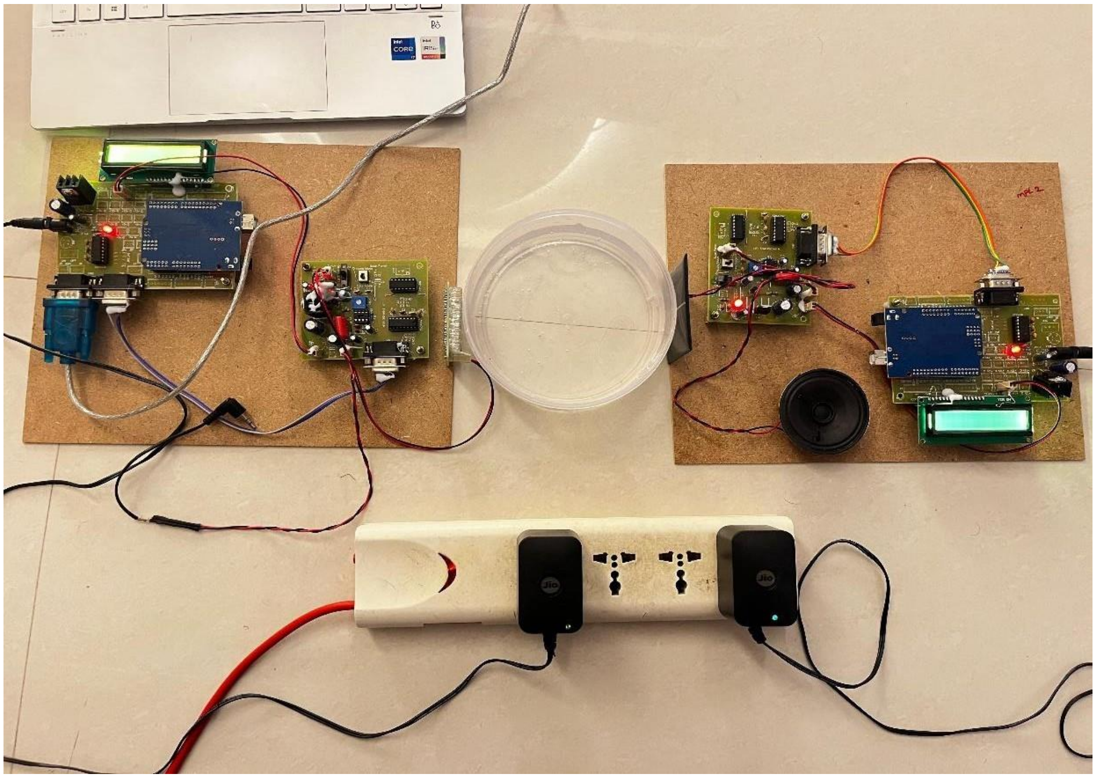

Fig 5.4: Demonstrating Underwater

Underwater data transmission via Li-Fi leverages the modulation of light intensity to encode digital information. The transmitter rapidly alters the light source, such as an LED or laser, according to the data, employing various modulation techniques like OOK or more complex schemes to maximize data capacity. This modulated light propagates through the water, with system design carefully considering water's optical properties, favoring wavelengths with lower attenuation like blue or green light, and implementing strategies to mitigate scattering. At the receiver, a photodetector captures these light fluctuations, converting them back into electrical signals that are then decoded to retrieve the original digital data. To ensure reliable communication in the challenging underwater environment, error correction codes and tailored communication protocols are crucial. This high-speed data transfer capability allows for seamless integration with underwater sensors, cameras, and AUVs, enabling real-time data streaming, high-bandwidth video transmission, and efficient command and control, ultimately enhancing underwater exploration and monitoring. Power efficiency remains a key consideration for practical deployments, driving research into energy-optimized components and system designs.

5.13 Overall Kit

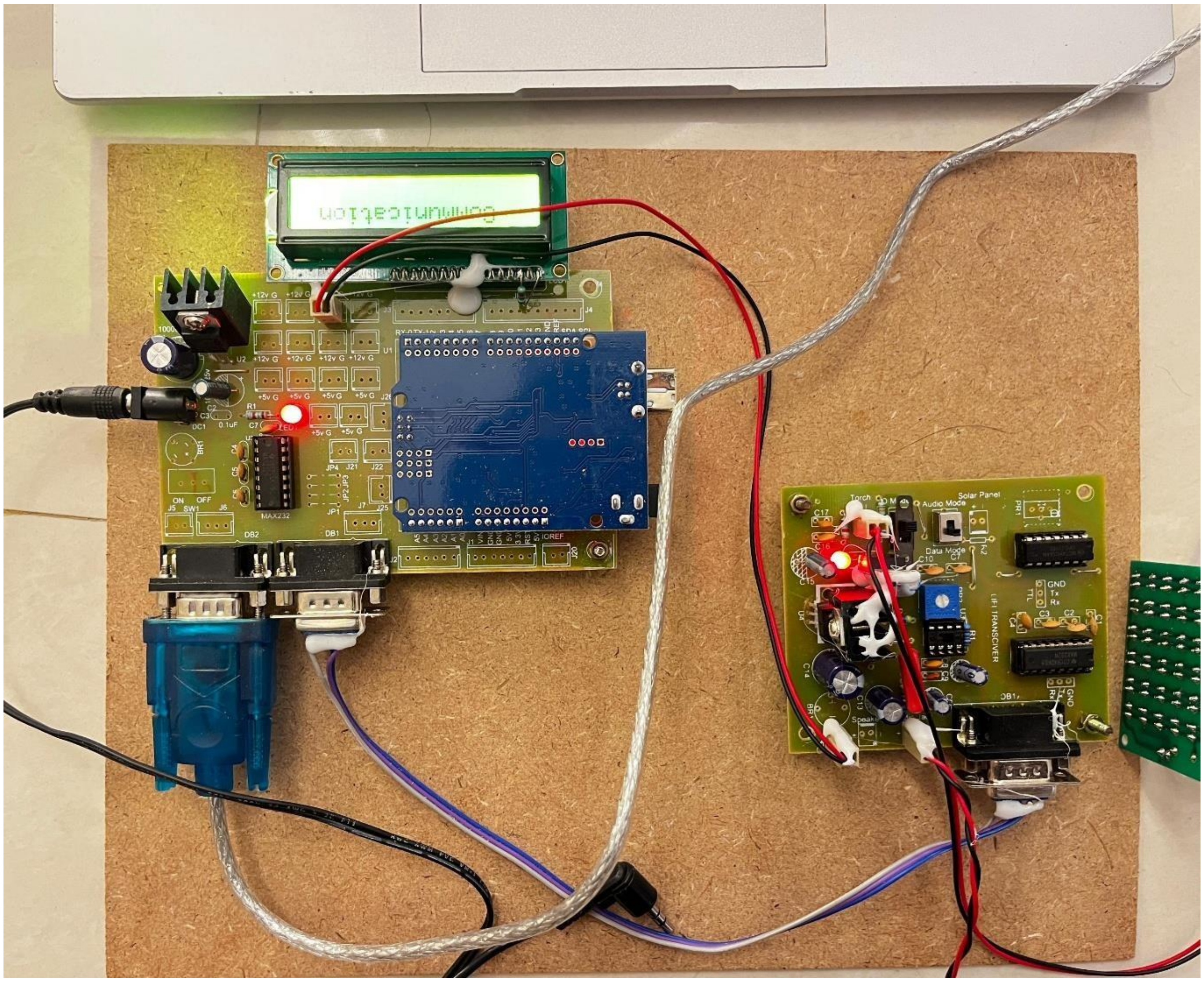

Fig 5.5: Overview of Kit

The hardware kit for an underwater Li-Fi system typically comprises a **transmitter unit** and a **receiver unit**. The **transmitter** includes a high-intensity light source, such as a blue or green LED or a laser diode, along with a microcontroller or a Digital Signal Processor (DSP) for data encoding and modulation of the light source's intensity. A power supply unit and potentially focusing optics to shape the light beam are also integral. The **receiver** consists of a highly sensitive photodetector (like a photodiode or photomultiplier tube) to capture the faint and potentially scattered light signals. This is coupled with signal conditioning circuitry, including amplifiers and filters, to process the received electrical signals.

CHAPTER 6

ADVANTAGES AND APPLICATIONS

CHAPTER 6

ADVANTAGES AND APPLICATIONS

6.1 ADVANTAGES

1. High Data Transfer Rate: Li-Fi can support higher data rates compared to traditional underwater communication methods like acoustic waves, enabling faster transmission of information.
2. No Interference from RF Signals: Traditional underwater communication methods based on RF signals (such as radio waves) suffer from high attenuation due to the water, especially seawater. Li-Fi, on the other hand, uses visible light and is less affected by these issues, making it more reliable for short-distance underwater communication.
3. Energy Efficient: Li-Fi systems tend to be more energy-efficient compared to radio frequency-based systems. LEDs, which are used in Li-Fi communication, consume less power and are more durable.
4. Improved Security: Light waves are confined to a specific area (line of sight), meaning that they do not spread widely like RF signals, making Li-Fi communication more secure. It’s difficult for unauthorized parties to intercept the communication.
5. Less Interference: Since light is less susceptible to interference from electromagnetic noise, Li-Fi-based systems are less affected by background noise, ensuring clearer data transmission.

6.2 APPLICATIONS

1. Underwater Exploration: Li-Fi can be used in underwater robotics (ROVs) or remotely operated vehicles (ROVs) for real-time data transmission, such as video or sensor data, during deep-sea exploration.
2. Submarine Communication: Li-Fi can provide a more reliable communication system for submarines or underwater vehicles, especially when traveling at shallow depths where RF communication is limited.
3. Environmental Monitoring: Li-Fi can be used in underwater sensors for monitoring marine environments, such as coral reefs or pollution levels, by transmitting data to a surface station without requiring wired connections.
4. Underwater Navigation: Li-Fi-based communication systems can be used for positioning and navigation of underwater vehicles by providing high-speed communication between different navigation points.

5. Marine Research: Scientists can use Li-Fi technology for transmitting data from research instruments placed on the ocean floor or in deep-sea environments to surface stations.
6. Smart Oceans and IoT: With the rise of the Internet of Things (IoT), Li-Fi communication can facilitate real-time data transmission between underwater IoT devices such as monitoring systems for fisheries, ships, or underwater sensors.
7. Underwater Communication Networks for Multi-Vehicle Operations: Li-Fi can enable real-time communication between multiple underwater vehicles in coordinated missions. This could enhance operations for oceanographic surveys, search-and-rescue missions, or oil and gas exploration by ensuring seamless data sharing among multiple vehicles in real-time.
8. Deep-Sea Mining Operations: Li-Fi can be used in deep-sea mining operations to transmit real-time data from mining equipment, sensors, and machinery on the ocean floor to control stations or vessels above, improving operational efficiency and safety.
9. Aquaculture and Fish Farming: Li-Fi can provide high-speed, secure communication in underwater cages or fish farms, enabling remote monitoring of water quality, fish health, and feeding systems. This technology could also assist in automating operations and integrating IoT devices for more efficient farming practices.
10. Underwater Archaeology: Li-Fi could be employed in underwater archaeology for transmitting high-resolution imagery, sensor data, and other research data in real-time from archaeological sites to research vessels or dive teams.
11. Marine Safety Systems: Li-Fi can be utilized for emergency communication systems in underwater habitats or during deep-sea expeditions, ensuring that data such as safety alerts, emergency protocols, or health monitoring information is transmitted instantly to the surface or supporting teams.
12. Underwater Robotics for Inspection and Maintenance: Li-Fi can enable communication for robots used in inspecting underwater infrastructure like oil rigs, pipelines, or cables. High-speed data transfer allows for the remote operation and monitoring of maintenance robots, increasing the efficiency of routine inspections or emergency repairs. : Li-Fi can be utilized for emergency communication systems in underwater habitats or during deep-sea expeditions, ensuring that data such as safety alerts, emergency protocols, or health monitoring information is transmitted instantly to the surface or supporting teams.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

Li-Fi based underwater communication is a promising technology that offers several advantages over traditional underwater communication methods. It is capable of transmitting high-speed data securely and without causing interference to marine life, making it a suitable choice for a wide range of underwater applications. As Li-Fi technology continues to develop and mature, it is expected to play an increasingly important role in underwater communication, enabling new applications and expanding our understanding of the underwater world. Overall, Li-Fi based underwater communication is a promising and rapidly developing technology that has the potential to transform underwater communication and exploration. With its unique advantages and wide range of potential applications, Li-Fi is poised to become a key enabler for the next generation of underwater technologies.

7.2 FUTURE SCOPE

The future of Li-Fi-based underwater communication is bright and full of possibilities. This emerging technology has the potential to revolutionize underwater communication, exploration, and research. With its high bandwidth, low latency, and security features, Li- Fi will enable a wide range of applications, including ubiquitous underwater connectivity, enhanced underwater exploration, environmental monitoring and protection, underwater infrastructure monitoring and maintenance, secure underwater communication for military and defense, underwater aquaculture and marine research, underwater maritime communication and navigation, oceanographic research and exploration, underwater disaster management and rescue operations, and underwater education and outreach. As Li-Fi technology continues to develop, we can expect to see even more innovative and transformative applications that will expand our understanding of the underwater world and make it a more accessible and interconnected space. With its high bandwidth, low latency, and security features, Li- Fi will enable a wide range of applications, including ubiquitous underwater connectivity, enhanced underwater exploration, environmental monitoring and protection, underwater infrastructure monitoring and maintenance, secure underwater communication for military and defense, underwater aquaculture and marine research, underwater maritime communication and navigation, oceanographic research and exploration.