SAVITRIBAI PHULE PUNE UNIVERSITY

A PROJECT REPORT ON

PHOTON - DATA TRANSFER USING LIGHT

SUBMITTED TOWARDS THE
PARTIAL FULFILLMENT OF THE REQUIREMENTS OF

BACHELOR OF ENGINEERING

BY

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Under The Guidance of

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CERTIFICATE

This is to certify that the Project Entitled

PHOTON - DATA TRANSFER USING LIGHT

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is a bonafide work carried out by them under the supervision of Prof. Deepali Javale and it is approved for the partial fulfillment of the requirement of Savtribai Phule Pune university, Pune for the award of the degree of Bachelor of Engineering (Computer Engineering).

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PROJECT APPROVAL SHEET

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PHOTON - DATA TRANSFER USING LIGHT

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Abstract

Data transmission has become a vital part in todays world. With number of service providers increasing, the radio spectrum requirement is increasing day by day. With lack of availability of radio spectrum there is a need to find an alternate medium to cope up with this demand. Also there is a requirement to provide a safe and secure data communication in RF-restricted areas. This project aims to tackle these problem by using the Li-Fi technology. The existing infrastructure has an effective implementation of LEDs for providing light. This project aims at combining the existing infrastructure with Li-Fi technology to demonstrate the working model.

In this project, secure and accurate data communication is implemented by using Arduino Uno R3, OP955 PN Photodiode and LEDs and thereby increasing power efficiency which will lead to a cost efficient model.

Acknowledgments

It gives us great pleasure in presenting the preliminary project report on **'PHOTON - DATA TRANSFER USING LIGHT'**.It is our proud privilege and duty to acknowledge the kind of help and guidance received from several people in preparation of this report. It would not have been possible to prepare this report in this form without their valuable help, cooperation and guidance.

We would like to take this opportunity to thank my project guide **Prof. Deepali Javale** for giving us all the help and guidance we needed. We are really grateful to her for her kind support. Her valuable suggestions were very helpful.

We are also grateful to **Prof. Bharati Dixit**, Head of Computer Engineering Department, MIT College of Engineering for making available library ,laboratory with all needed software platforms and a complete congenial environment to work for our project .

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SYNOPSIS

1.1 Project Title

PHOTON - Data Transfer using light

1.2 Project Option

In-house project

1.3 Internal Guide

Prof. Deepali Javale

1.4 Technical Keywords (As per ACM Keywords)

Please note ACM Keywords can be found :

1. C.2 Computer-communication networks.
2. C.3 Real-time and embedded systems.
3. C.2.5 Local and Wide-Area Networks.
4. C.2.1 Wireless communication.

1.5 Problem Statement

To demonstrate the transfer of data using light for improved speed and energy efficiency.

1.6 List of modules/functionalities

1. Transmitter
2. Receiver
3. Micro controller
4. Digital data transfer

1.7 Mathematical Model

Let S be our system,

- S = I, O, F, Success, Failure, NDD, DD
- I= Inputs
- O = Outputs
- F = Functions
- NDD = Non-Deterministic Data
- DD = Deterministic Data
- I = Any type of digital data to transmitter device (raw data) = I1, I2, I3, I4, I5
  - I1 = Text file
  - I2 = Audio file
  - I3 = Video file
  - I4 = Image file
- O = Corresponding Data received from transmitter device (raw data decoded on the receiver side)
- F = F1,F2,F3,F4,F5
  - F1 = Accepting the user input digital data
  - F2 = Encoding the digital data into optical form
  - F3 = Sending the optical data though LED
  - F4 = Receiving the optical data though photodiode
  - F5 = Decoding the optical data into digital form
- Success = Lossless data transmission is achieved.
- Failure = Data packet loss, Connection failure
- DD = Frequency of data transmission, bit rate
- NDD = Input data from user (may be a text file, audio file, video file, image file or any arbitrary file)

1.8 Names of Conferences / Journals where papers can be published

- IEEE/ACM Conference/Journal 1
- Conferences/workshops in IITs
- Central Universities or SPPU Conferences
- IEEE/ACM Conference/Journal 2

1.9 Plan of Project Execution

Please refer Annex C for the planner .

CHAPTER 2

TECHNICAL KEYWORDS

2.1 Area of Project

IOT and Embeded Systems

2.2 Technical Keywords

Please note ACM Keywords can be found :

1. Li-Fi
2. Internet of things
3. LAN/WAN
4. LED
5. VLC
6. Data Transmission

PERFORMANCE OF SYSTEMS

1. Fault tolerance
2. Performance attributes
3. Reliability, availability, and serviceability

2.3 Softwares and Environments

- PROGRAMMING LANGUAGES
  - Arduino
  - Python

CHAPTER 3

INTRODUCTION

3.1 Project Idea

All of us have increasingly become dependent on the internet some way or the other. It is impossible to think of a day in our lives, when we are not connected to the internet. We are using the internet for a variety of purposes, most important amongst them being sharing of data. In such All of us have increasingly become dependent on the internet some way or the other. It is impossible to think of a day in our lives, when we are not connected to the internet. We are using the internet for a variety of purposes, most important amongst them being sharing of data. In such scenarios we want out data to be transferred quickly and efficiently. Low internet speeds can be quite annoying. One of the most common way to achieve the internet access is cellular network. But the availability of radio spectrum is limited. The number of devices in use is rapidly increasing. We need to find alternatives to the traditional methods of communication quickly.

Towards this effort, in 2011, Professor Harald Haas from the University of Edinburgh in the UK, suggested an idea called Data through illumination . He used fiber optics to send data through LED light bulbs. Light modulation certainly is not a new concept, but we are looking to move things forward and enable connectivity through omnipresent LED bulbs. The term for this technology is Li-Fi. With Li-Fi, we can connect to the internet simply by being within range of an LED beam, or we could conceivably transmit data using our car headlights. The ramifications of this are huge, especially with the internet of things in full swing and the much-mooted spectrum crunch expected to bite increasingly hard in the coming years.

3.2 Motivation of the Project

The main motive behind this project was to address the problem of depletion of the radio frequency spectrum. With the spectrum depleting at a high rate there is a need to provide alternate solutions to address this problem. Li-Fi technology is one such solution which uses the existing infrastructure which comprises of LEDs. These LEDs can be used a medium to deliver networked, mobile, high speed communication.

Visible light communications (VLC) works by switching the current to the LEDs off and on at a very high rate, too quick to be noticed by the human eye. Although LiFi LEDs would have to be kept on to transmit data, they could be dimmed to below human visibility while still emitting enough light to carry data. 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 is not necessary for Li- Fi to transmit a signal; light reflected off the walls can achieve 70 Mbit/s. Hence Li-Fi provides a secure data communication.

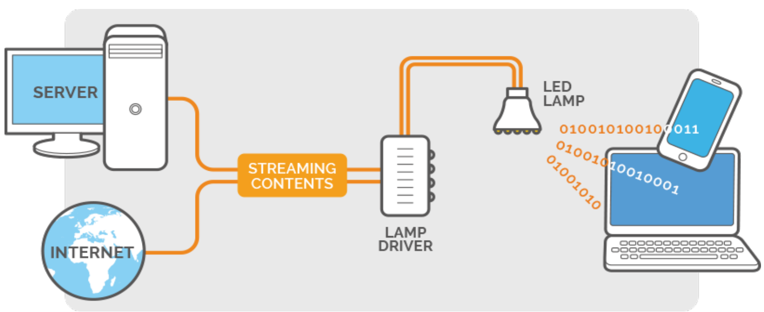
In addition to this, this technology has the advantage of being used in electromagnetic sensitive areas such as nuclear power plants.

3.3 Literature Survey

3.3.1 Overview of LI-FI Technology

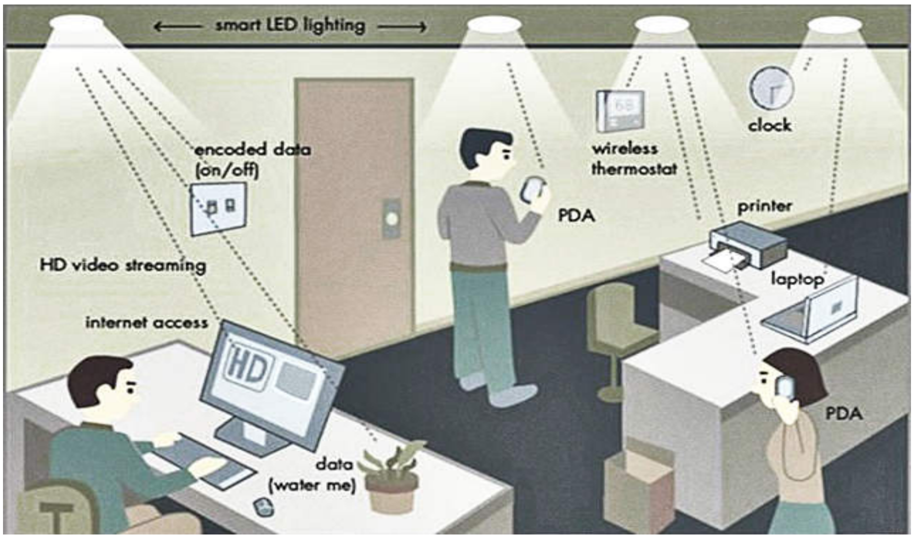
This technology is based on the Visible Light Communication which uses the visible light for data communication. In VLC, we use a source of illumination which can not only produce illumination but also send information using the same light. So we can say that VLC is illumination along with communication. Now imagine a torch which we might use to send some sort of a signal, maybe morse code. We can do so manually by switching the torch ON and OFF repeatedly. But in this case, we may not be able to use the torch as an efficient source of illumination, so we cannot strictly consider it as VLC as per our definition. Now suppose we switch the torch ON and OFF very quickly using a computer system. In this case, due to the rapidity of the motion of switching between ON and OFF states, the torch appears to be ON constantly, and additionally, we also cannot see the data being transmitted. We would, of course, need a receiver.

Figure 3.1: Li-FI model



Literally, any form of information that can be sent using a light signal that is visible to humans could be considered to be VLC, but by our definition we should be able to see the light, but cannot see the data. So although there seems to be no universally agreed definition of VLC, we can at least agree what we mean by VLC. The sending of the data in the above mentioned manner has been made possible by the widespread use of the LED bulbs. These bulbs can be switched ON and OFF very rapidly thus permitting us to send the required data via light. The rapid adoption of LED light bulbs has created a massive opportunity for VLC. The problem of congestion of the radio spectrum utilized by Wi-Fi and cellular radio systems is also helping to create the market for VLC.

Figure 3.2: Li-Fi Enviornment



3.3.2 Advantages of Li-Fi pver Wi-Fi

- Li- Fi uses light rather than radio frequency signals so are intolerant to disturbances.
- VLC could be used safely in aircraft without affecting airlines signals.
- Integrated into medical devices and in hospitals as this technology doesnt deal with radio waves, so it can easily be used in all such places where Bluetooth, infrared, Wi-Fi and internet are broadly in use.
- Under water in sea Wi-Fi does not work at all but light can be used and hence undersea explorations are good to go now with much ease.
- There are billions of bulbs worldwide which just need to be replaced with LEDs to transmit data.

- Security is a side benefit of using light for data transfer as it does not penetrate through walls.
- On highways for traffic control applications like where Cars can have LED based headlights, LED based backlights, and they can communicate with each other and prevent accidents.
- Using this Technology worldwide every street lamp would be a free data access point.
- The issues of the shortage of radio frequency bandwidth may be sorted out by Li-Fi.

CHAPTER 4

PROBLEM DEFINITION AND SCOPE

4.1 Problem Statement

To demonstrate the transfer of data using light for improved speed and energy efficiency.

4.1.1 Goals and objectives

Goal and Objectives:

1. To achieve high-Speed data transfer
2. Successful connectivity between transmitter and the receiver.
3. Data integrity maintained throughout data transmission process.
4. Secure data transmission is achieved.
5. Overall goals and objectives of system, input and output description with necessary syntax, format etc are described

4.1.2 Statement of scope

To achieve high speed data transmission using visible light in order to provide an alternative to currently available systems and leverage already available infrastructure of LED's to achieve it.

4.2 Major Constraints

- Transmitter and receiver must be in straight line.
- Light waves can easily be blocked and cannot penetrate thick walls like the radio waves can.
- If the apparatus is set up outdoors, it would need to deal with changing weather conditions.
- Light beam transmitting the data should not be interrupted.

4.3 Methodologies of Problem solving and efficiency issues

- The single problem can be solved by different solutions. This considers the performance parameters for each approach. Thus considers the efficiency issues.

4.4 Outcome

- Achieving high speed data transfer.
- Allowing use of wireless data transmission in RF restricted areas.
- A secured channel for data transmission is achieved.
- One to one communication with guaranteed intrusion avoidance.
- An alternative to tradition data transmission is developed witout having any additional infrastructure cost.
- QoS Quality of Service.
- Flexible to run on various platforms and serve heterogeneous types of data.

4.5 Applications

Many areas where LiFi system provide a reliable, secure, cheaper and ultra-highspeed communication infrastructure have already been launched worldwide, so we can summarize some of them as follows:

- Airplanes: Since Wi-Fi during flights with most of airlines is forbidden, and therefore limited, LiFi can be a suitable replacement for wireless communication. The use of this technology within aircraft cabin has more advantages since significant amounts of cabling can be saved resulting in cost saving, reduced weights and flexible layout design.
- Hospitals: LiFi can be enhanced in hospitals also where the Wi-Fi is forbidden. They can be used in different advanced medical equipment to communicate with each other for fast data interpretation, for example

- Petrochemical industry: Since various radioactive chemicals are used for processing, the industry does not allow RF.
- Nuclear power plants: LiFi can be a useful replacement of Wi-Fi in electromagnetic sensitive areas such as nuclear power plants as it does not cause any electromagnetic interference. Power plants need fast, inter-connected data systems to monitor things like demand, grid integrity and core temperature. The savings from proper monitoring at a single power plant can add up to hundreds of thousands of dollars
- In home and office appliances: LiFi system can be integrated in home appliances such as: secure systems, freeze, central heating systems, TVs, clocks and so on to reduce energy consumptions for an intelligent energy management.
- Smart lighting: Public lighting can be used to provide LiFi hotspots and monitoring lighting and data can be used to the same communications and sensor infrastructure.
- Vehicle and traffic lights: LED devices can be installed as headlights and taillights developing an intelligent transport system. Traffic lights can also move to LED with the benefit of road safety and traffic control.
- Underwater: Light propagate underwater where radio frequencies cannot be used because of salty, high conductivity and high attenuation environment. Since cables creates threads in communication undersea water, can be replaced with LiFi transmitters. Also they can send data to submarines, to surface as well as to divers with their head lights.
- In health surveillance: The wearable LiFi transmitter like LED bracelets, ear rings, wrist watches and so on, allow continuously monitoring individual state of health providing instant notice to family doctor of any significant changes occurred in health condition by connecting to the internet and updating the information online in real time.
- Indoor navigation: Where the LED lights sources are used, like shopping malls, cinema, theatres, government offices, work offices or any indoor locations, the LiFi technology allows an indoor navigation (pinpointing an object to within about 10 cm) and offers orientation information (useful for knowing, for example, which direction a customer is looking)

4.6 Hardware Resources Required

- 2x Arduino Uno R3 (Atmega328)
- 1x OP955 P-N Photo-diode
- 2x C503C-WAN- CBADB151 Cool White LED
- 1x 1602A LCD 16x2 Display
- 1x 10 - 5M Potentiometer
- 1x 10k Resistor
- 1x 100k Resistor
- 1x 510k Resistor

4.6.1 Arduino UNO R3 Specs:

- Micro-controller: 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 of which 0.5 KB used by boot-loader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

4.7 Software Resources Required

Platform :

1. Operating System:
   - Linux/Windows 32/64 bit Operating System
2. IDE:
   - Arduino IDE
   - Python IDLE
3. Programming Language:
   - Python : It is mainly used for connection of PC and arduino via serial port.
   - C language
   - Arduino programming

CHAPTER 5

PROJECT PLAN

5.1 Project Estimates

The development model fit for our project would be Waterfall Model. The system does not follow an iterative approach and attempts to start with the full specification of requirements. Each phase must be completed before the next phase can begin and there is no overlapping in the phases. The waterfall model illustrates the development process in a linear sequential flow; hence it is also referred to as a linear-sequential life cycle model. This means that any phase in the development process begins only if the previous phase is complete. Consider a waterfall lifecycle model which consists of the following detailed phases:
Phases of Waterfall Model:-
Waterfall Model slices the system functionality into increments (portions). In each increment, a slice of functionality is delivered through cross-discipline work, from the requirements to the deployment. The unified process groups increments/iterations into phases of:
1. Requirements Gathering
2. Analysis
3. Design
4. Coding
5. Testing
6. Maintenance

1. Requirements:-
   The first phase of requirements gathering identifies the requirements (functional and non-functional) at a high level but in enough detail that work can be estimated. The functionality and the limitations of the system are chalked out in this phase.

2. Analysis:-
   As per the requirements, the software and hardware needed for the proper completion of the project is analyzed in this phase. Right from deciding what kind of structure of the robot will be suitable, to the object detection and following algorithms for the smooth functioning of the robot, are decided at this stage.

3. Design:-
   Using the gathered requirements, system design is done. System design is important because it describes what is going to get developed in the next phase. If during the design phase, it is noticed that there are some more requirements for designing the code or necessity to

change the proposed structure, the analysis phase is revisited and the design phase is carried out according to the new set of resources.

4. Coding:-
Based on the algorithm or flowchart designed, the actual coding of the algorithms is carried out. This is the stage where the idea and flowchart of the application is physically created or materialized. A proper execution of the previous stages ensures a smooth and easier implementation of this stage.

5. Requirements:-
The first phase of requirements gathering identifies the requirements (functional and non-functional) at a high level but in enough detail that work can be estimated. The functionality and the limitations of the system are chalked out in this phase.

6. Testing:-
With the coding of the algorithms complete, the testing of the written code now comes into scene. Testing checks if the object is detected without giving false positive values of detection and if the robot is following the objects movements. If there are any flaws, the development process must step back to the design phase.

7. Maintenance:-
This is the last stage of development in the waterfall model. A proper execution

5.2 Cost Estimates

Sr. No.	Component	Cost estimate (Rs.)
1	Arduino Uno R3	500-1000
2	OP955 Photodiode	250-500
3	LED	100-200

Table 5.1: Cost Estimates

5.3 Risk management

This section discusses Project risks and the approach to managing them.

5.3.1 Risk Identification

1. Have top software and customer managers formally committed to support the project? Top software and target customer managers likes the idea of the project and formally committed to support the project fully. They are looking forward for the completion of the project.

2. Are requirements fully understood by the engineering team and its customers? The requirements are fully understood by the project team and customers as well.

3. Does the software engineering team have the right mix of skills? Everyone in the project team is working on the different phase of the project. The project work is well distributed among team.

4. Are project requirements stable? The project requirements are stable.

5. Is the number of people on the project team adequate to do the job? Definitely the number of people on the project for this project are adequate to do a job.

6. Do all customer/user constituencies agree on the importance of the project and on the requirements for the system/product to be built? All the customers/user constituencies agree on the importance of the project and on the requirements of the product to be built.

5.3.2 Risk Analysis

Risk management is concerned with identifying risks and drawing up plans to minimize their effect on a project. A risk must also have a probability. There are three types of risks- project, performance and technology.

- Project risks affect schedule or resources.

- Performance risks affect the quality or performance of the software being developed.

- Technology risks affect the technical aspects of the project.

5.3.2.1 Performance Risks

The performance of the application depends on the speed of execution and efficiency with which it recognizes the objects.

5.3.2.2 Project Risks

Project risk involves damage to important electronics components which will affect project schedule.

5.3.3 Overview of Risk Mitigation, Monitoring, Management

Risk ID	1
Risk Description	Damage to electronic components
Category	Functionality
Source	This can be seen while the system is up and running.
Probability	Medium
Impact	High
Response	Mitigate
Strategy	Using regulated power supply or replacing the electronics in worst case.
Risk Status	Identified

Table 5.2: Risk 1

Risk ID	2
Risk Description	Obstacles lying in between transceivers
Category	Functionality
Source	This can be detected when data reception stops.
Probability	Medium
Impact	Medium
Response	Mitigate
Strategy	Avoid obstacles in between line of sight
Risk Status	Identified

Table 5.3: Risk 2

Risk ID	3
Risk Description	Transmitter loses connection while transmitting data
Category	Functionality
Source	This can be detected when there is abrupt breakage while receiving data
Probability	Medium
Impact	Medium
Response	Mitigate
Strategy	Retry transmission
Risk Status	Identified

Table 5.4: Risk 3

Probability	Value	Description
High	Probability of occurrence is	more than 75%
Medium	Probability of occurrence is	26-75 %
Low	Probability of occurrence is	less than 25%

Table 5.5: Risk probability definitions

Impact	Value	Description
Very high	more than 10%	Schedule impact or Unacceptable quality
High	5-10%	Schedule impact or Some parts of the project have low quality
Medium	less than 5%	Schedule impact or Barely noticeable degradation in quality Low Impact on schedule or Quality can be incorporated

Table 5.6: Risk impact definitions

5.4 Project Schedule

5.4.1 Project task set

Major Tasks in the Project stages are:
Task 1 : Requirement Analysis
Task 2 : Design
Task 3 : Development
Task 4 : Testing
Task 5 : Documentation

5.5 Team Organization

Our team for B.E. final year project consists of a team of students and a college professor as an internal college guide making collaborative effort

5.5.1 Team structure

Each and every member of team is responsible for identification of the problems and constraints, proposing problem solving methodologies, breaking the problems into components,identifying the approaches for implementation and documentation. Prof. Deepali Javale, Assistant Professor, Department of Computer Engineering, MITCOE is the internal college guide for providing thorough domain guidance, doubt removal, suggesting and approving solution approaches and ensuring timely completion of activities. for the fulfillment and implementation of the project problem statement.

Name	Roll No.
Sahil Santosh Patil	B120384299
Ameya Milind Phadnis	B120384303
Chinmay Atul Sashittal	B120384321
Rohan Sanjay Shahane	B120384326

Table 5.7: Team members

5.5.2 Management reporting and communication

- Meeting/Reporting with project guide: Every Monday and Friday
- Team communication : Monday and Friday
- Mechanism for report and communication :
  1. Telephonic conversation
  2. Emails
  3. Meeting

CHAPTER 6

SOFTWARE REQUIREMENT SPECIFICATION

6.1 Purpose

The purpose of this project is to demonstrate a fast, accurate and secure data transmission using light medium and thereby increasing power efficiency which will lead to cost efficient model.

6.2 Usage scenario

6.2.1 User Profiles

Actors : User_1(Sender), Transmitter (LED), Receiver (Photo-diode), User_2(Receiver)

6.2.2 Use cases

The project shall have 4 main use cases. They are:

1. Taking digital data as input from end user
2. Sending the data through LED
3. Receiving the optical data using photo diode
4. Receiving the corresponding digital data sent by end user 1 at the receiver side

All the actors present in the use cases, along with a brief description of use cases is given in the table below :

Sr. No.	Use case	Description	Actors	Assumptions
1	Taking digital data as input from end user	The end user 1 (sender) should provide the input to the transmitter (input may be simple text, audio file, video file, image file)	End User 1 (Sender)	User enters a valid file as input to be sent from the transmitter side.
2	Sending the data through LED	The input received from the user will be encoded into optical form and will be sent through LED	LED	The digital data is properly encoded into optical form suitable for transmission through LED.
3	Receiving the optical data using photodiode	The optical data sent through LED will be received by photodiode at the receiver side	Photodiode	Proper placement of photodiode in order to receive data.
4	Receiving the corresponding digital data sent by end user 1 at the receiver side	The data received by photodiode will be decoded into digital form and will be given to end user 2 (receiver)	End User 2 (Receiver)	The data received by the photo diode is given intact to the decoder.

Table 6.1: Use cases

6.3 Use Case Diagram

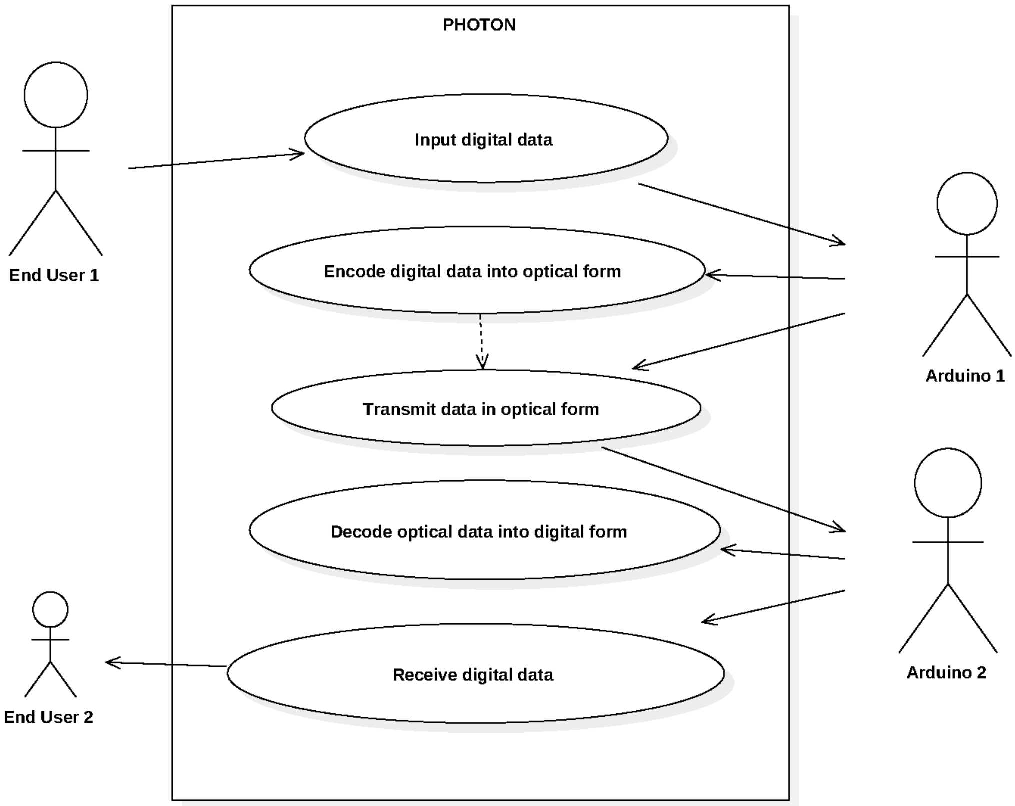


Figure 6.1: Use-case diagram

6.4 Data flow diagram

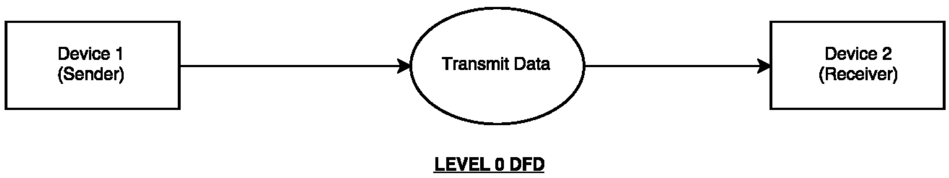


Figure 6.2: Data flow diagram: level 0

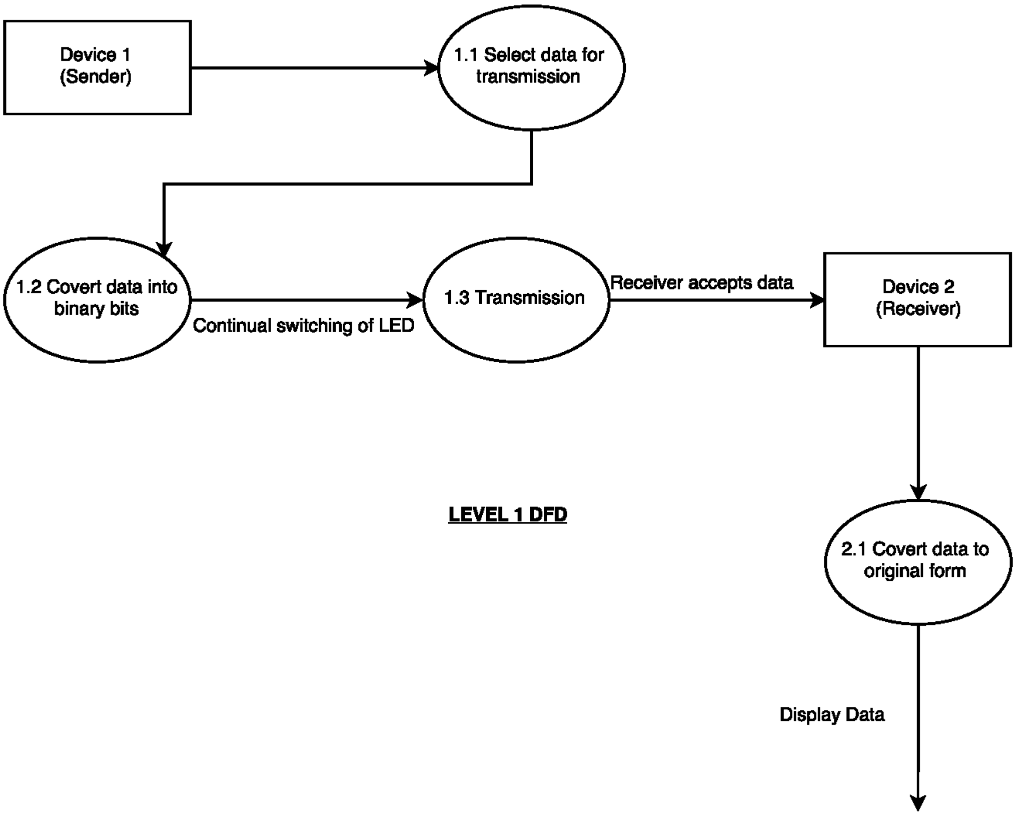


Figure 6.3: Data flow diagram: level 1

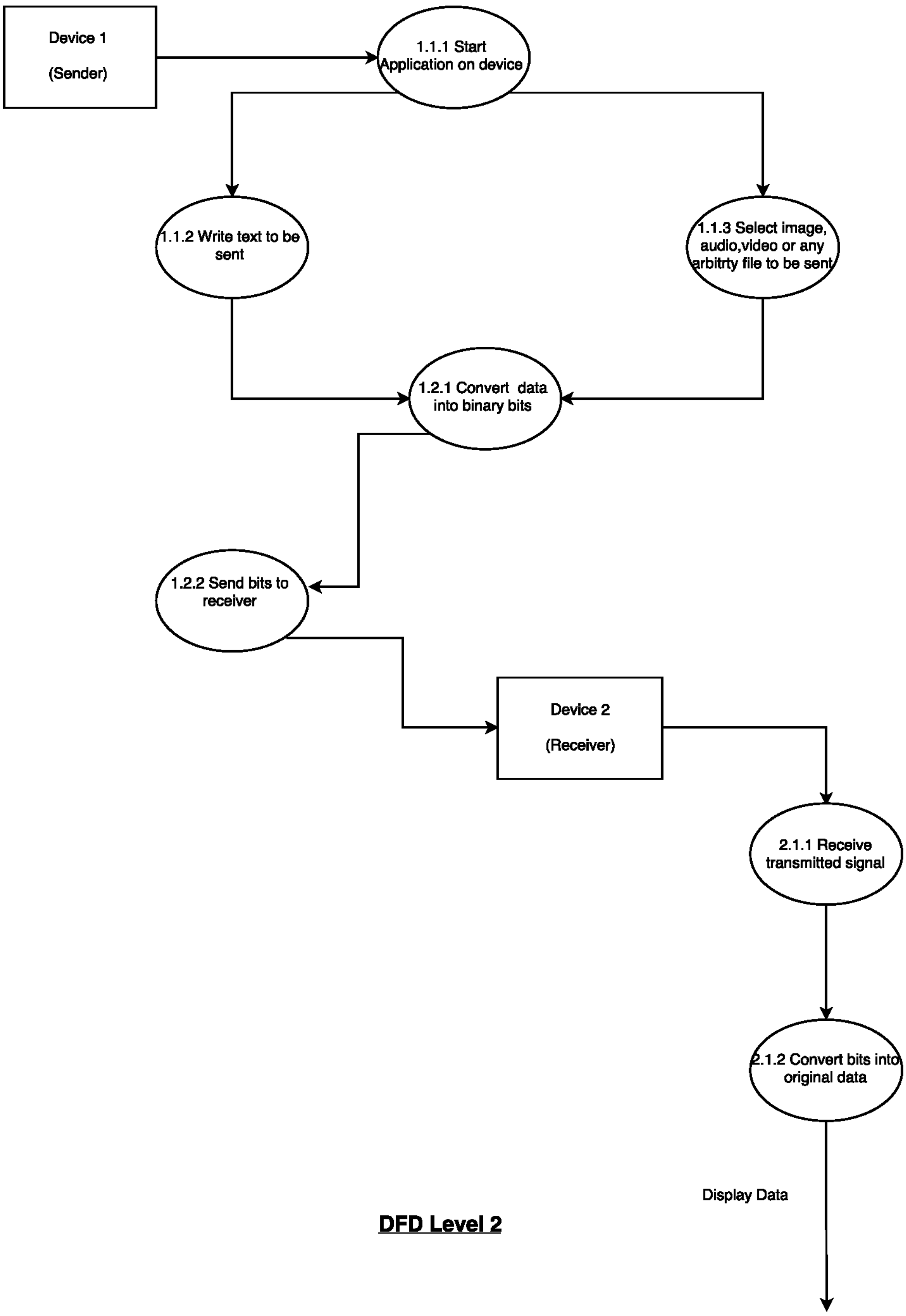


Figure 6.4: Data flow diagram: level 2

6.5 Activity Diagram

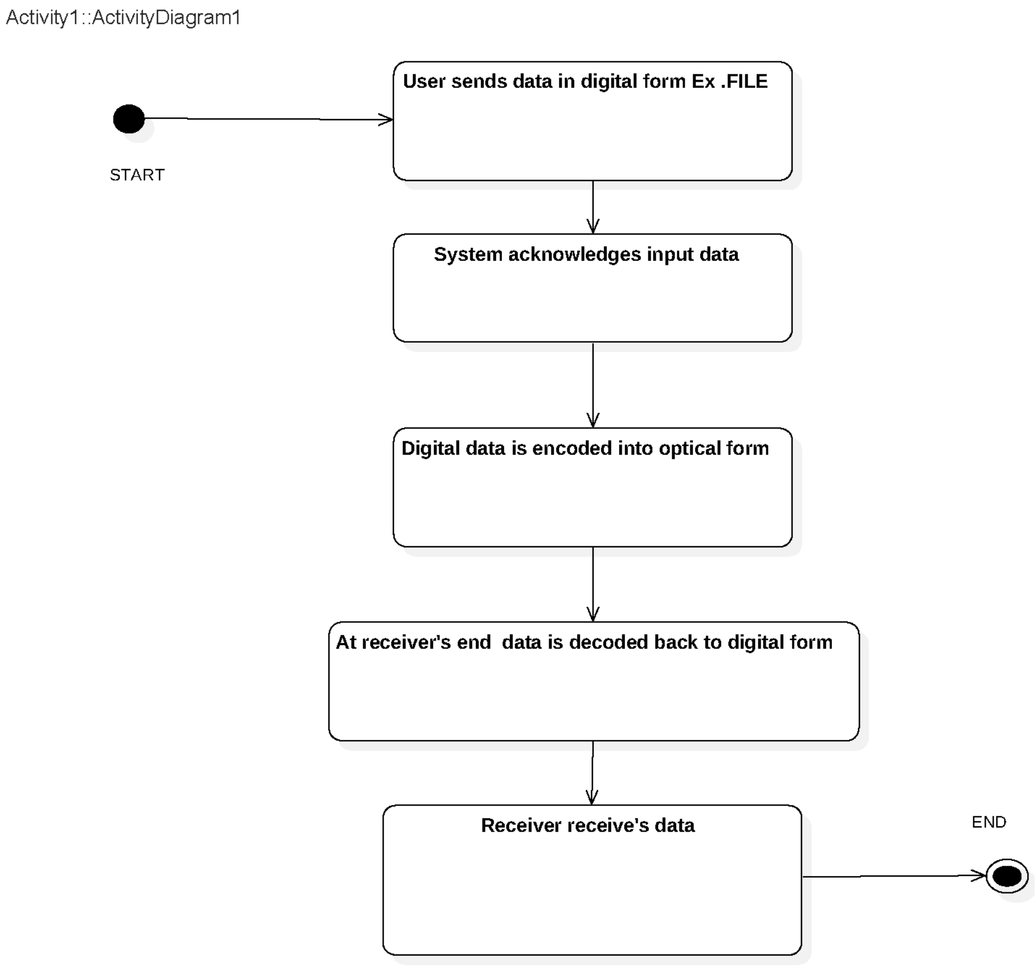


Figure 6.5: Activity Diagram

6.6 Non functional requirements

- Interface requirements:
  - The interface between transmitter and receiver must be completely obstacle free.
  - The interface must be high quality.
- Performance Requirements:
  - Response time for of receiver should be low.
  - Should be able to handle voluminous data.
- Reliability
  - The communication should be robust and reliable.
  - The system should always be available and never go down.
- Portability: Should be portable across all platforms.
- Security: The system provides secure line of sight data communication.
- Usability: The performance should remain consistent with all the added features. Users should be able to use the system as per their needs.

CHAPTER 7

DETAILED DESIGN DOCUMENT USING ANNEXURE A AND B

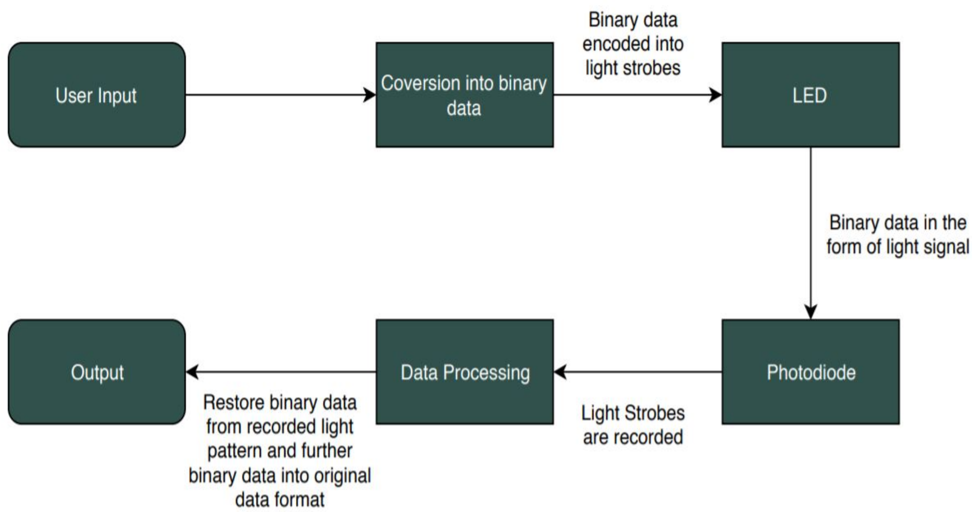
7.1 Introduction

This document specifies the design that is used to solve the problem of Product.

7.2 Architectural Design

A description of the program architecture is presented.

Figure 7.1: Block Diagram



Overall Flow :

1) Taking input data from user for transmission
2) Input data is converted into binary data
3) Binary data is encoded into light strobes
4) Photodiode receives the light signal
5) Light Strobes are recorded and processed
6) Binary data is restored from recorded light pattern and then converted into original format and given as output

CHAPTER 8

PROJECT IMPLEMENTATION

8.1 Introduction

In spite of the latest technical advancements there hasnt been much development in establishing an efficient data transmission medium to replace the traditional radio frequency mediums. With the RF spectrum depleting at a fast pace due to the exponential increase in the number of end users there is a dire need to find an alternative. Also, this alternate medium should be cost-effective, secure and robust for efficient data transmission. Visible light Communication is the domain that provides point to point wireless data communication. Li-Fi is a technology that uses visible light for wireless communication between devices. Along with having 10 times more bandwidth than the traditional RF spectrum, Li-Fi technology can seamlessly integrate data and lighting utility infrastructures and significantly reduce energy consumption.

The proposed work deals with wireless transmission of data through illumination of LEDs. User input is encoded into optical form at the senders end which is sent through strobing of LEDs. This strobing is captured at the receivers end with the help of photodiode and converted back to its original form as sent by the user.In this project, we attempt to demonstrate the concept of Li-Fi through a cost-efficient model.

8.2 Tools and Technologies Used

1. Hardware

   (a) Arduino Uno: The Arduino UNO is a widely used open-source microcontroller board based on the ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board features 14 Digital pins and 6 Analog pins. The ATmega328 on the Arduino Uno comes preprogrammed with a bootloader that allows to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

   (b) Photodiode: For this project, we used OP955 photodiode. The OP955 device consists of a PIN silicon photodiode molded in a clear epoxy package which allows spectral response from visible to infrared light wavelengths. The very wide receiving angle provides relatively even reception over a large area. Wide receiving angles and spectrum was decisive characteristics for diode selection.

(c) Led: For the experiment we used Cree 5mm Round LED C503C. This LED offers superior light output and dependable performance. It also provides extremely stable light output over long periods of time. Which is the key to LiFI performance.

(d) 16x2 LCD display: This is generic display used as an output device for the received message.

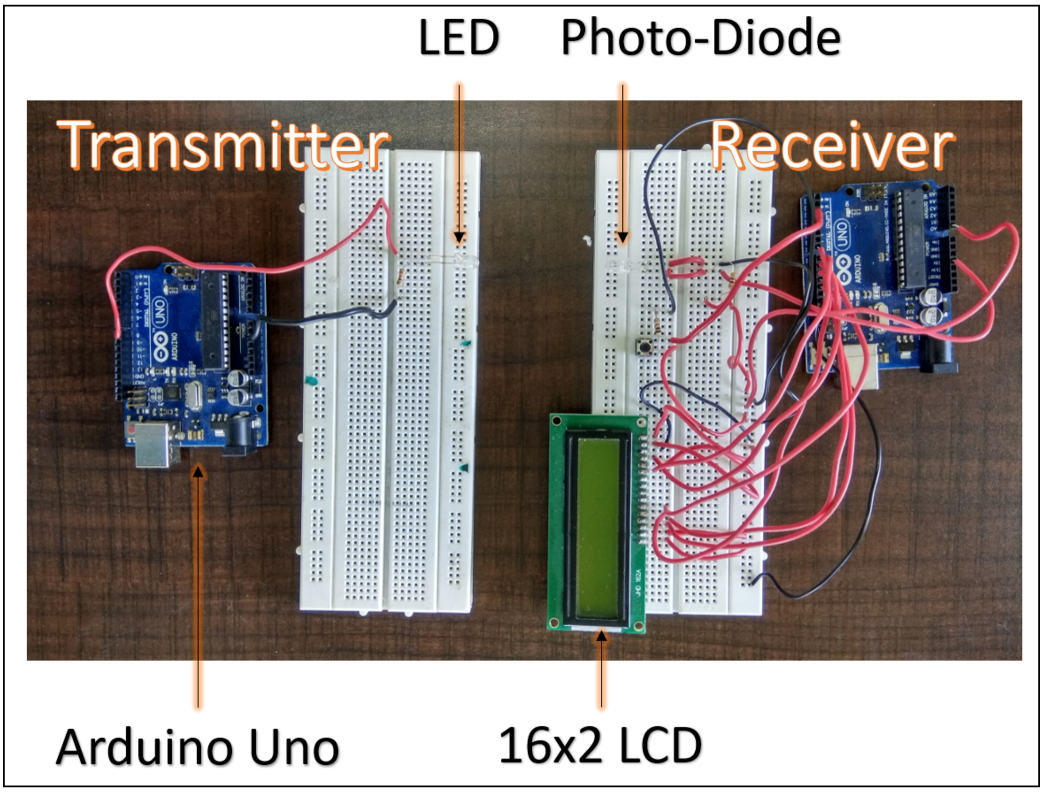
2. Software

   (a) Arduino IDE: The Arduino integrated development environment (IDE) is a cross-platform application that is written in Java. It provides simple one-click mechanisms to compile and upload programs to an Arduino board. The Arduino IDE supports the languages C and C++ using special rules of code structuring. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

   (b) Python PySerial: PySerial module encapsulates the access for the serial port. It provides backends for Python running PC. The module named serial automatically selects the appropriate backend. It is used to connect to Arduino for executing python code.

8.3 Experimental setup

Figure 8.1: Experimental setup

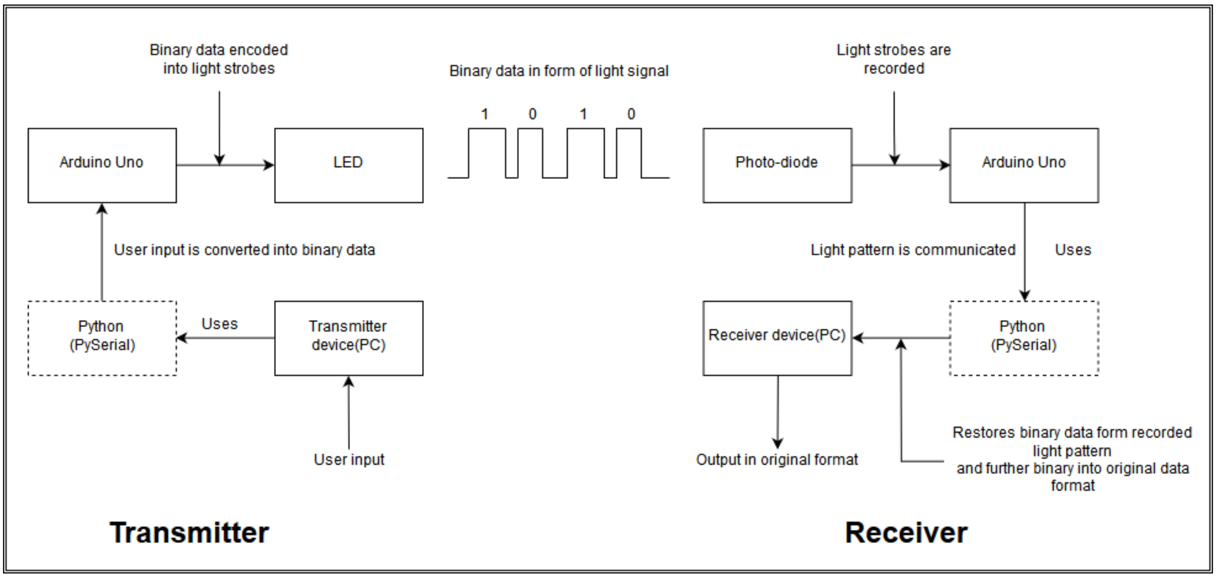


In the experimental setup (Fig.2), after making hardware connections, we connect Arduino to PC through USB port. Arduino IDE natively detects Arduino and the code can then be uploaded and executed on Arduino Uno. When it comes to python execution, we need to import PySerial library to communicate to Arduino as python by itself cannot detect and communicate through serial port. Python is used to take input and convert it into asci equivalent.

8.4 Working

The Working can be divided into two parts as follows,

Figure 8.2: Schematic block diagram



1. Transmitter end
   (a) Input: User enters input message through python console. (PC -python)
   (b) Conversion: Input String is converted into its ASCII value string. This ASCII string is then converted into its binary equivalent string representation. (PC -python)
   (c) Transmission: The Binary string is then sent to Arduino via PySerial interface. The Arduino then reads the Binary string and modulates the intensity of LED accordingly. Thus, according to binary data LED is made to strobe i.e. Turn on and off. (Arduino)
2. Receiver end
   (a) Light sensing: Photodiode will detect light intensity changes and communicate the same to Arduino.
   (b) Time measurement: Arduino will the measure the time intervals for which LED remains ON/OFF. This time information is then communicated to PC via PySerial interface. (Arduino)
   (c) Bit Recognition: Time information for each signal is converted into corresponding bit value. In such a way, Bit String is reconstructed. (PC -python)

(d) Conversion: Bit String is converted into corresponding ASCII representation string. This ASCII String is converted into its Character representation. Thus, Original message is reconstructed. (PC -python).

(e) Display Output: Message string is sent back to Arduino via PySerial. Arduino then displays the message on the 16x2 LCD. (Arduino)

8.4.1 Flowcharts

Figure 8.3: Transmitter flow

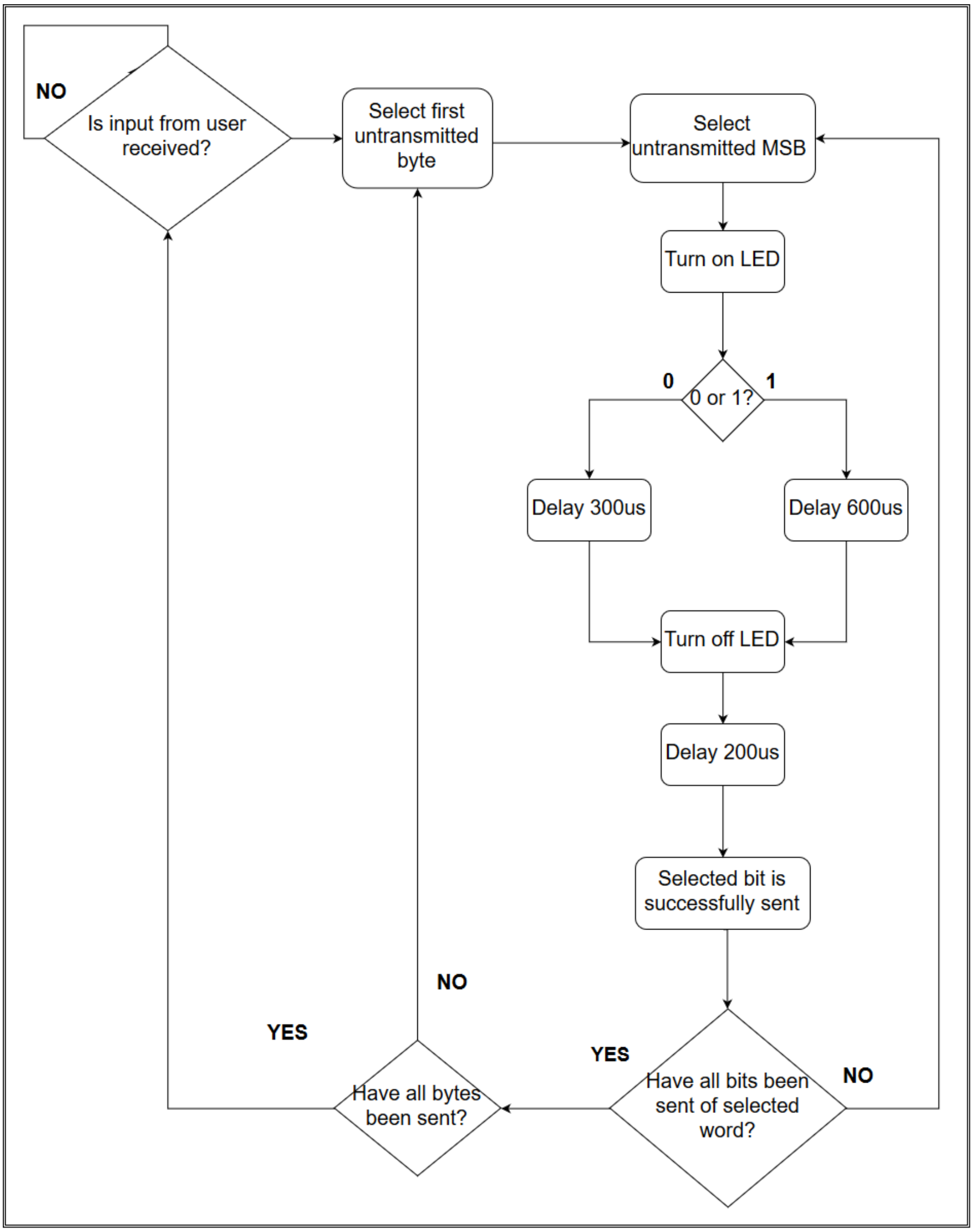
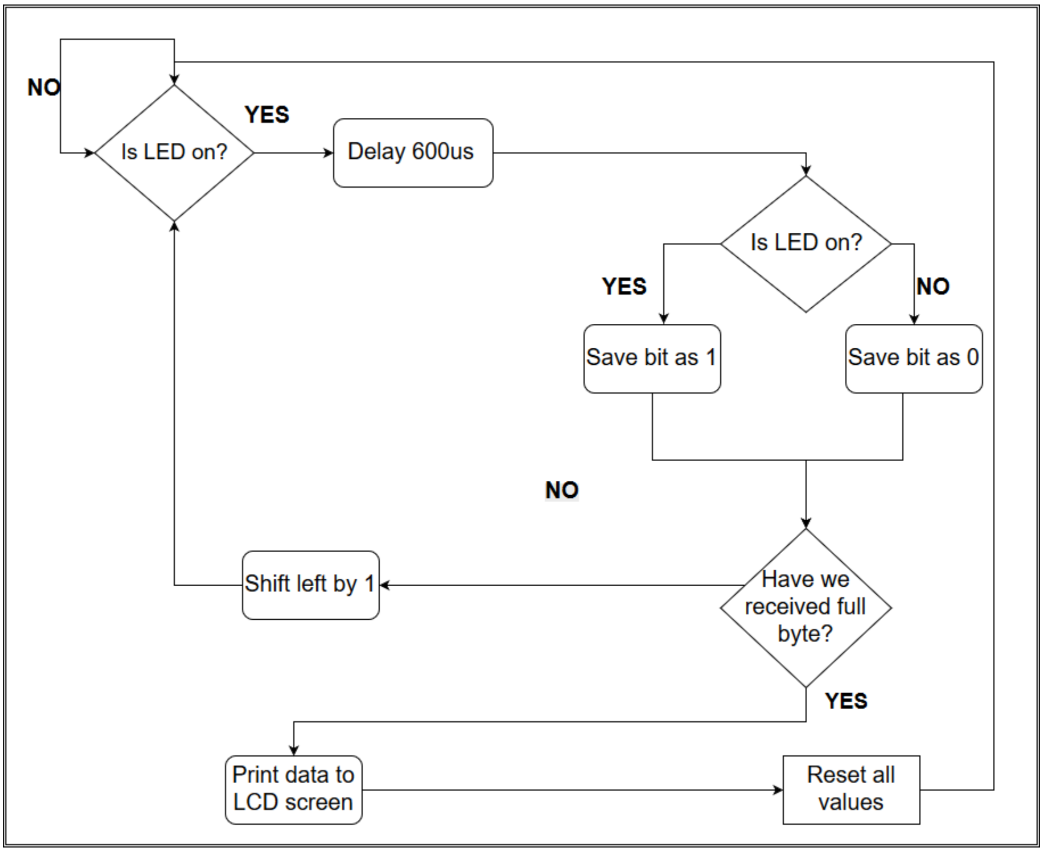


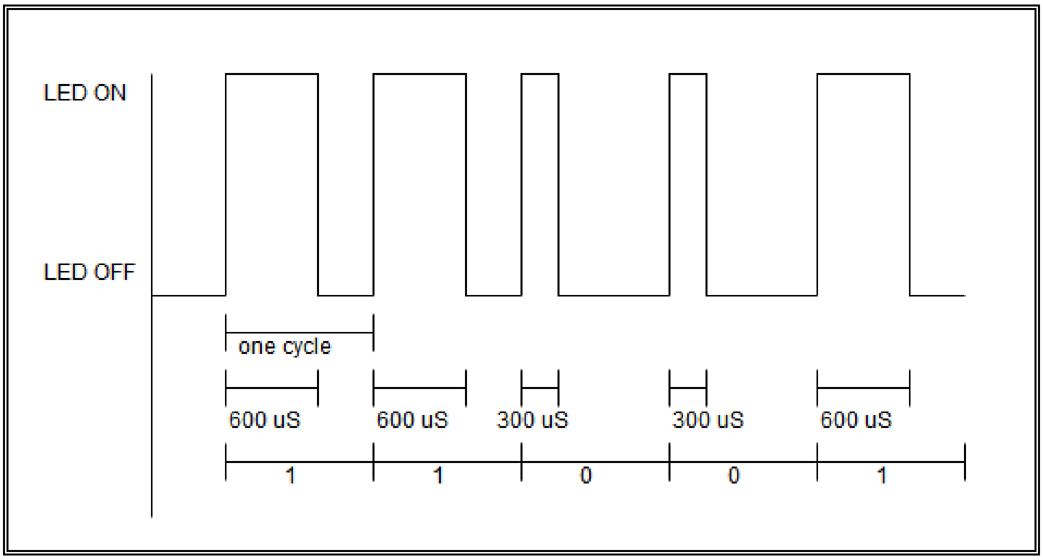
Figure 8.4: Receiver flow



8.4.2 Example

Consider were sending a number, say 9. 9 is represented as 1001 in binary. For digital one, the LED will go on for 600us and off for 200us. For digital zero the led will go on for 300us and off for 200us. Thus, the LED blinking pattern would be [ON-600us—-OFF-200us—ON-300us—OFF-200us—ON-300us—OFF-200us—ON-600us—OFF-200us]. This pattern will be detected and converted by receiver into number 9 thereby, receiving the sent data.

Figure 8.5: Waveform



CHAPTER 9

SOFTWARE TESTING

1. **Test tool selection**
   Manual testing is done as and when required

2. **Test Cases and Test Results**

   - **Unit Testing**
     Unit testing is the testing of an individual unit or group of related units. It falls under the class of white box testing. It is often done by the programmer to test that the unit he/she has implemented is producing expected output against given input.
     - Photo-Diode
     - LED
     - LCD Display
     - Arduino

Test ID	Component Tested	Expected Results	Actual Results
1	Photo-Diode	Accurate reading	Light intensity recorded accurately
2	LED	Accurate strobing	Desired strobing accuracy achieved
3	LCD Display	Display correct data	Correct data is displayed
4	Arduino	Proper working	All functionality tested and work properly

Table 9.1: Unit Testing

- **Functional Testing**
  Functional testing is the testing to ensure that the specified functionality required in the system requirements works. It falls under the class of black box testing.
  - Data Transmission
  - Data Reception

Test ID	Component Tested	Expected Results	Actual Results
1	Data Transmission	Proper encoding of data into light	Data encoded accurately
2	Data reception	Conversion of light pattern into Data	Light pattern successfully converted into original data

Table 9.2: Functionality Testing

- **System Testing**
  System testing is the testing to ensure that by putting the software in different environments (e.g. Operating Systems) it still works. System testing is done with full system implementation and environment. It falls under the class of black box testing.
  - Operations in unfavourable conditions(dusty, windy and rainy)
  - Operations in light interference environment

CHAPTER 10

RESULTS

10.1 Screen shots and Images

Figure 10.1: Transmitter console

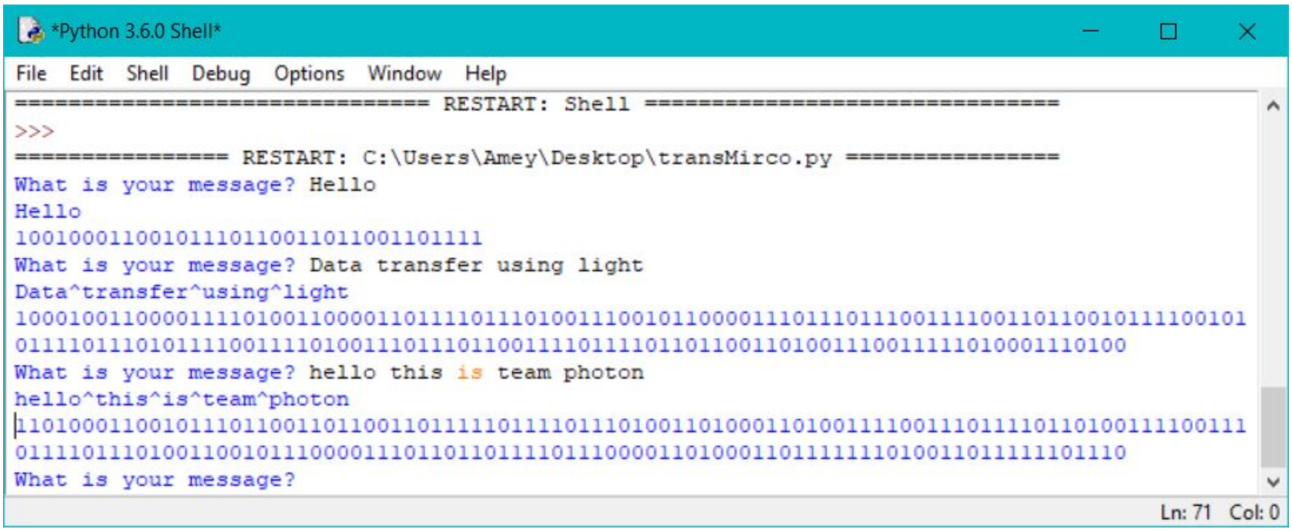


Figure 10.2: Receiver Console

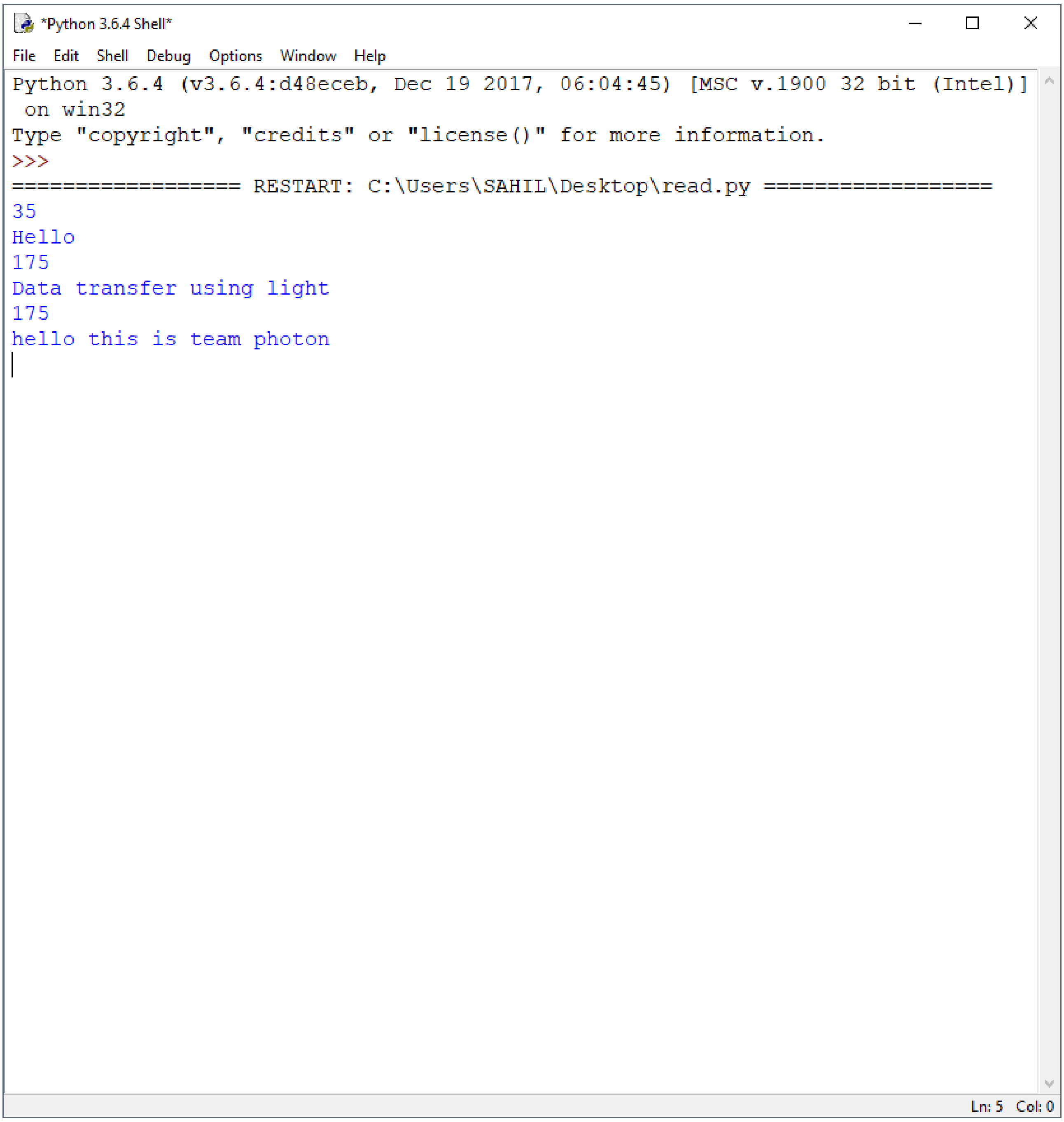
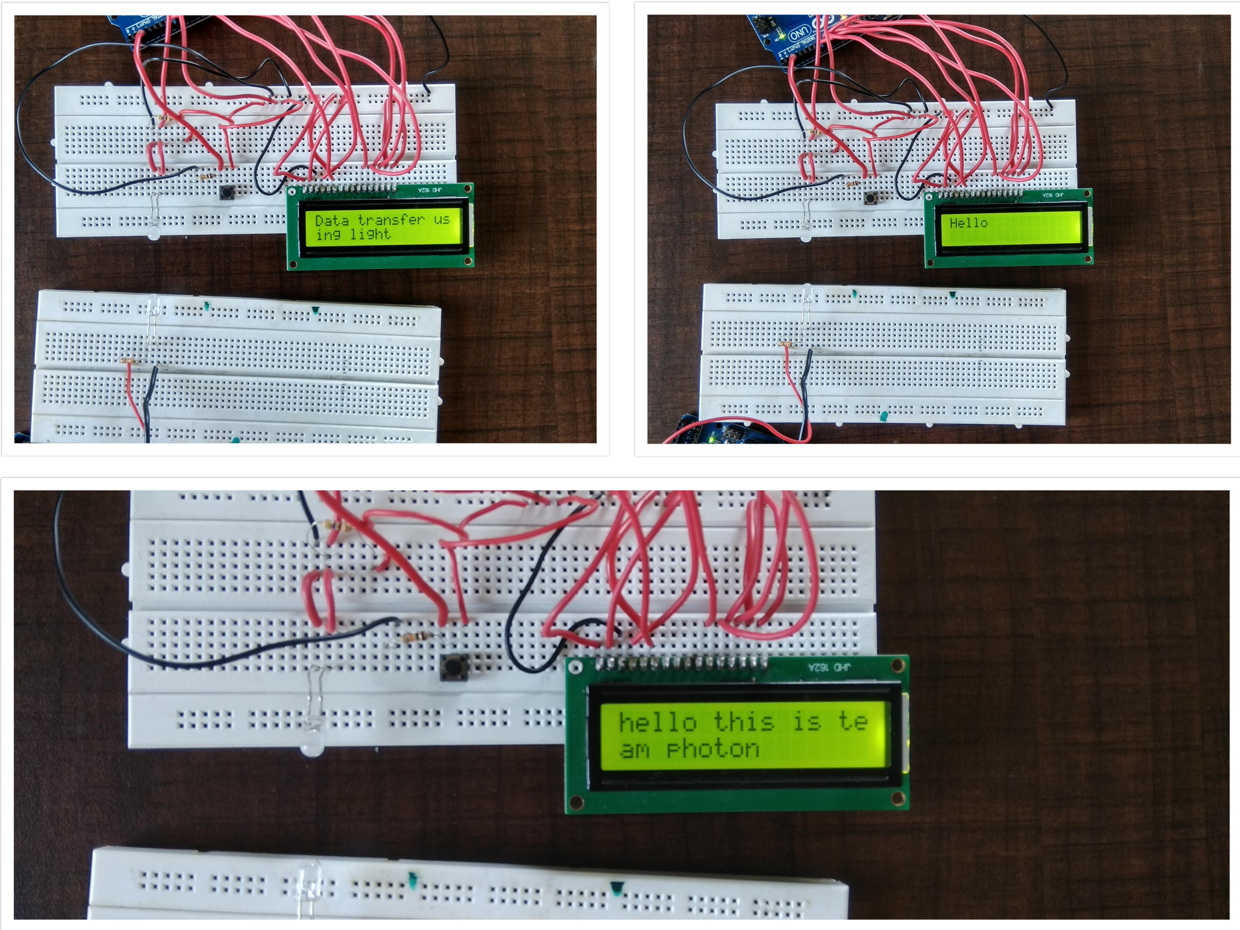


Figure 10.3: LCD Display messages



CHAPTER 11

DEPLOYMENT AND MAINTENANCE

11.1 Installation and un-installation

Installation of Arduino IDE and Python
Arduino IDE and Python needs to be installed at the client's side to use communicate to arduino through computer.

1. Download the arduino IDE application from site:https://www.arduino.cc/en/Main/Software

2. Install the arduino IDE with driver.

3. Download Python desktop installer from site:https://www.python.org/downloads/

4. Install the Python.

5. Initially,we need to set up proper connections with arduino uno. This includes selecting correct COM port, connectiong the arduino board to PC on USB port

6. Upload the code for transmitter and receiver to respective arduino boards

7. Application can be uninstalled by going to Settings-¿System Applications- ¿¿¿¿ Select app and click Uninstall.

11.2 User help

1. Make sure the transmitter and receiver are in line of sight.

2. make sure there are no other light sources abruptly flashing on the receiver

CHAPTER 12

CONCLUSION AND FUTURE SCOPE

Future Scope:

- **Electromagnetic Sensitive Area:**
  In electromagnetic sensitive areas like aircraft cabins and nuclear power plants, establishing a secure and safe communication network is one of the main challenges. This challenge can be tackled by implementing Li-Fi based communication network, which is extremely safe at the same time provides high-speed data transfer.

- **Peer to Peer Traffic Network:**
  An efficient network can be established by using the head-lights and tail-lights of the vehicle using the Li-Fi technology. This inter-linked communication network can help direct and monitor traffic.

- **Transforming the existing infrastructure:**
  The existing infrastructure has an effective implementation of LEDs for providing light. Combining this existing infrastructure with Li-Fi technology model, an efficient Li-Fi implementation can be demonstrated.

- **Secured communication between the models:**
  Unlike traditional wireless means of transmission, no other device other than transmitter and receiver can capture the packets being sent. This means we are completely avoiding risk of man in the middle attack, packet sniffing etc.

Conclusion:

- Thus, A new approach for transferring data is introduced.

- This approach overcomes most of the limitations of present data transmission methods

- If this technology can be put into practical use, every bulb can be used similarly like a Wi-Fi Access point.

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1. S. Chatterjee, S. Agarwal, A. Nath, *Scope and Challenges in Light Fidelity(LiFi) Technology in Wireless Data Communication*; International Journal of Innovative Research in Advanced Engineering (IJIRAE), 2015.

2. M. Leba, S. Riurean, A. Ionica, *Lifi the Path to a New Way of Communication*; Institute of Electrical and Electronics Engineers(IEEE), 2017.

3. R. Mahendran, *Integrated Lifi(Light Fidelity) For Smart Communication Through Illumination*; S. Chatterjee, International Conference on Advanced Communication Control and Computing Technologies (ICACCCT), 2016.

4. R. Suarez, *Data transfer using light*; California polytechnic state university, San Luis obispo senior project spring 2014.

5. Harald Hass, *Wireless data from every light bulb*;Ted Talk 2011.

ANNEXURE A

LABORATORY ASSIGNMENTS ON PROJECT ANALYSIS OF ALGORITHMIC DESIGN

A.1 Knowledge canvas

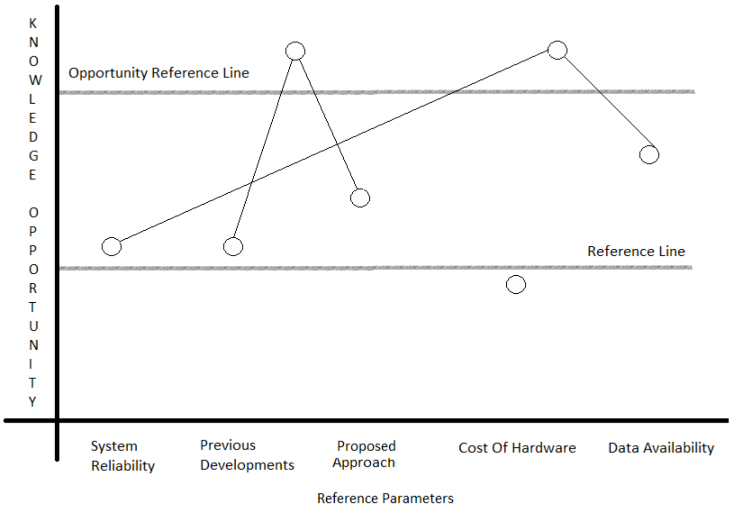


Figure A.1: Knowledge canvas

A.2 Idea Matrix

I	D	E	A
Increase : Accessibility	**Drive** : Driven by need of alternate medium	**Educate** : LiFi Technology	**Accelerate** : Data transmission
Improve : Security	**Deliver** :Connectivity	**Eliminate** : RF signals	**Avoid** : Extra infrastructure cost
Ignore : Interference	**Decrease** : Power consumption	**Evaluate** : Network performance	**Associate** : Existing infrastructure

Table A.1: Idea Matrix

A.3 Mathematical Model

Let S be our system,

- S = I, O, F, Success, Failure, NDD, DD
- I= Inputs
- O = Outputs
- F = Functions
- NDD = Non-Deterministic Data
- DD = Deterministic Data
- I = Any type of digital data to transmitter device (raw data) = I1, I2, I3, I4, I5
  - I1 = Text file
  - I2 = Audio file
  - I3 = Video file
  - I4 = Image file
- O = Corresponding Data received from transmitter device (raw data decoded on the receiver side)
- F = F1,F2,F3,F4,F5
  - F1 = Accepting the user input digital data
  - F2 = Encoding the digital data into optical form
  - F3 = Sending the optical data though LED
  - F4 = Receiving the optical data though photodiode
  - F5 = Decoding the optical data into digital form
- Success = Lossless data transmission is achieved.
- Failure = Data packet loss, Connection failure
- DD = Frequency of data transmission, bit rate
- NDD = Input data from user (may be a text file, audio file, video file, image file or any arbitrary file)

A.4 Project problem statement feasibility assessment NP-Hard, NP-Complete or satisfiability issues

P-Type Problem : Consider a file of size x, number of low bits y, number of high bits z, number of separations w
Delay for representing low bit - 1000 microseconds
Delay for representing high bit - 500 microseconds
Delay for representing bit separation - 5000 microseconds
Time required to trans code 1 bit : k microseconds
Time for trans coding file = Size of file * time required to transcode 1 bit = x * k
Time required to transfer data from transmitter to receiver = number of low bits * 1000 + number of high bits * 500 + number of separations * 5000 = y*1000 + z*500 +w*5000
Hence, considering the above number of operations i.e. the complexity, we can say that the problem of data transmission using LiFi is a P type problem.

ANNEXURE B

LABORATORY ASSIGNMENTS ON PROJECT QUALITY AND RELIABILITY TESTING OF PROJECT DESIGN

B.1 UML Diagrams

B.1.1 Use Case Diagram

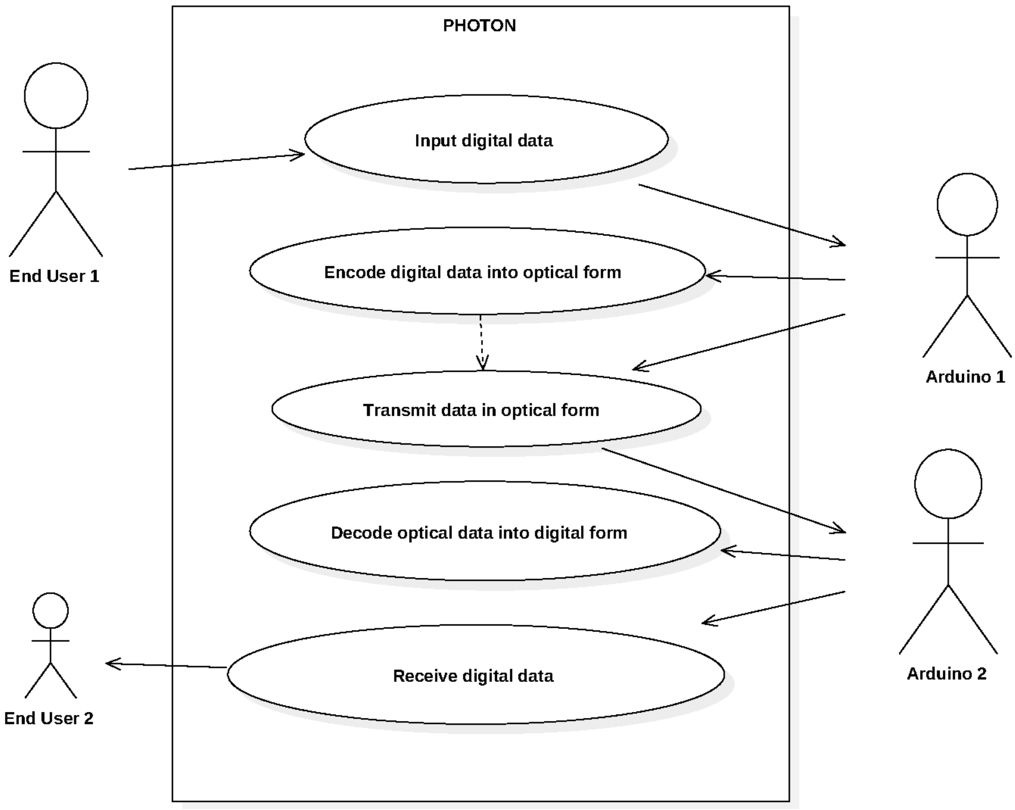


Figure B.1: Use-case diagram

B.1.2 Data flow diagram

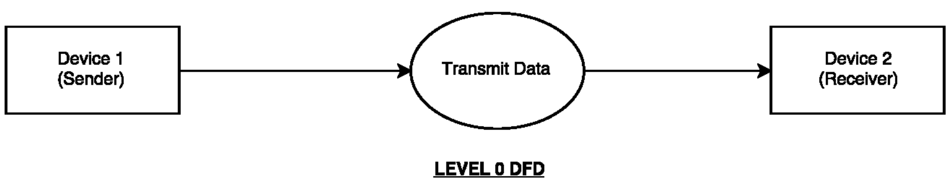


Figure B.2: Data flow diagram: level 0

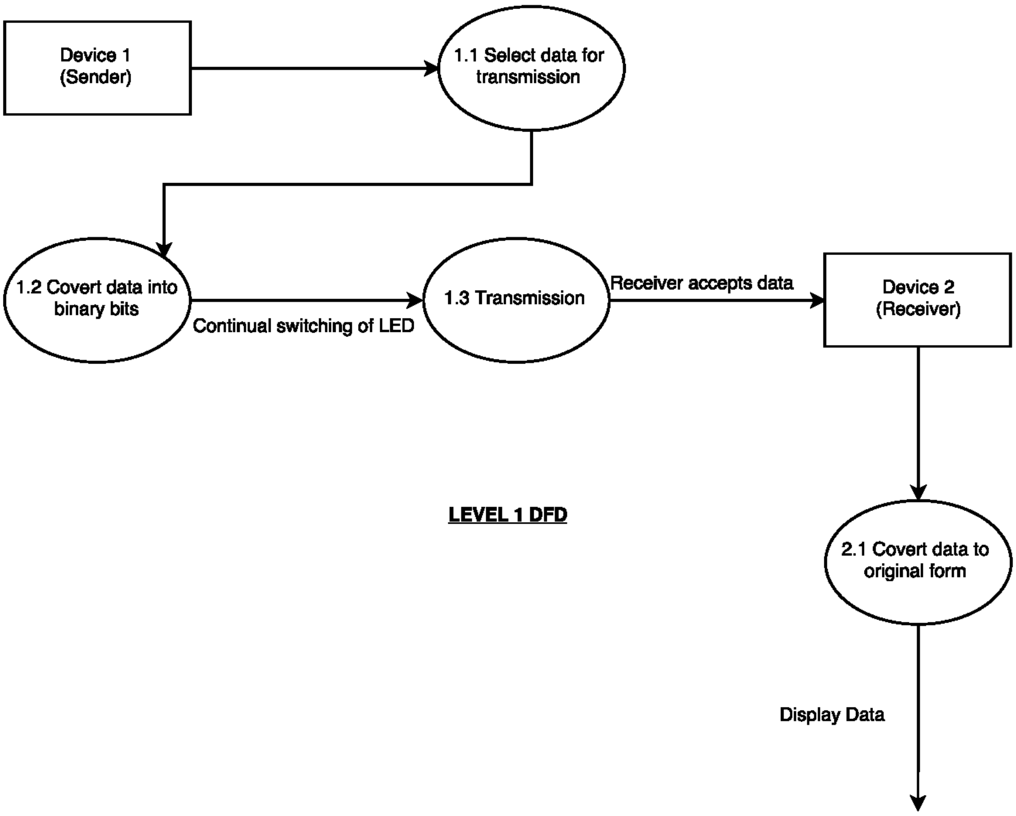


Figure B.3: Data flow diagram: level 1

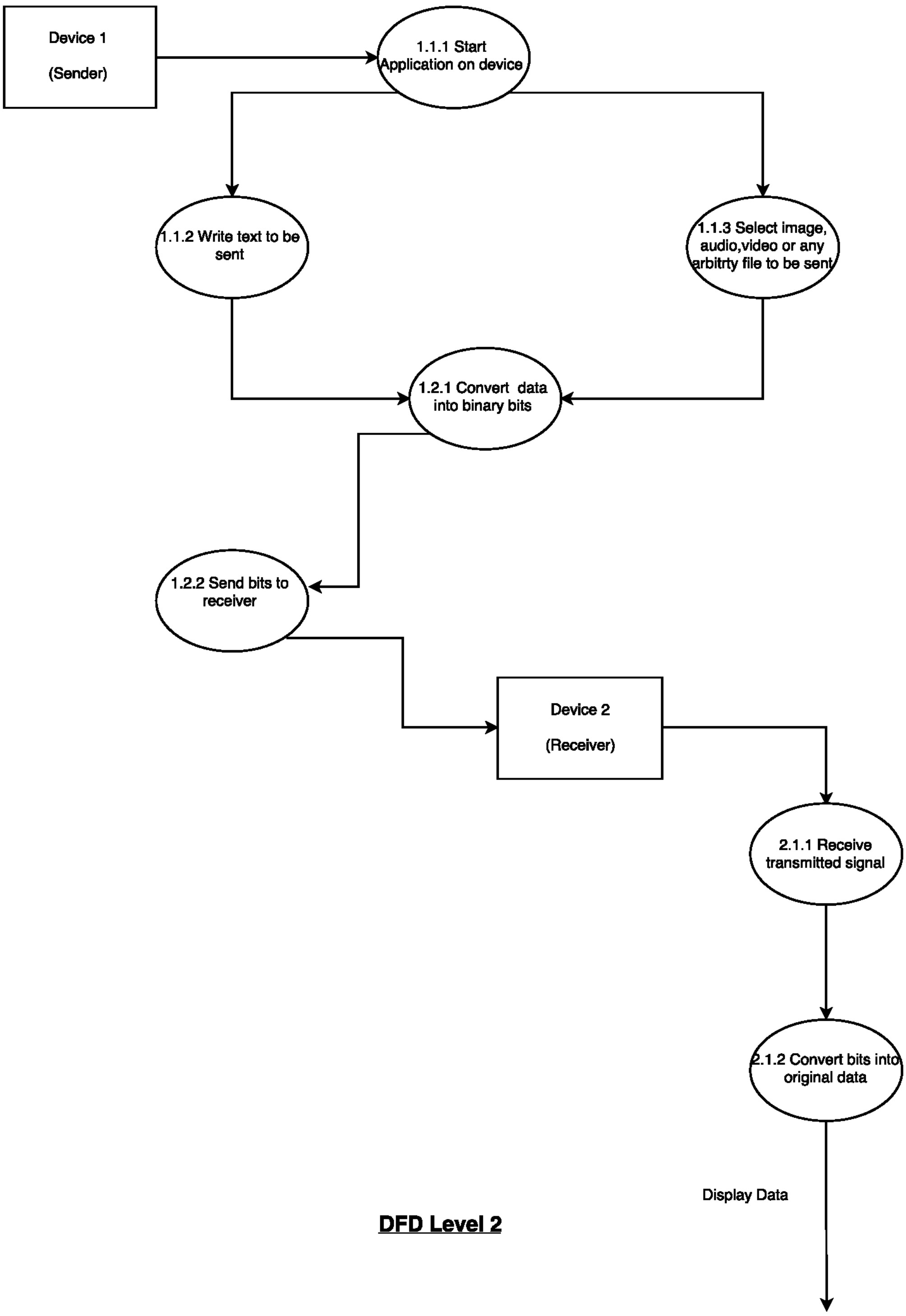


Figure B.4: Data flow diagram: level 2

B.1.3 Activity Diagram

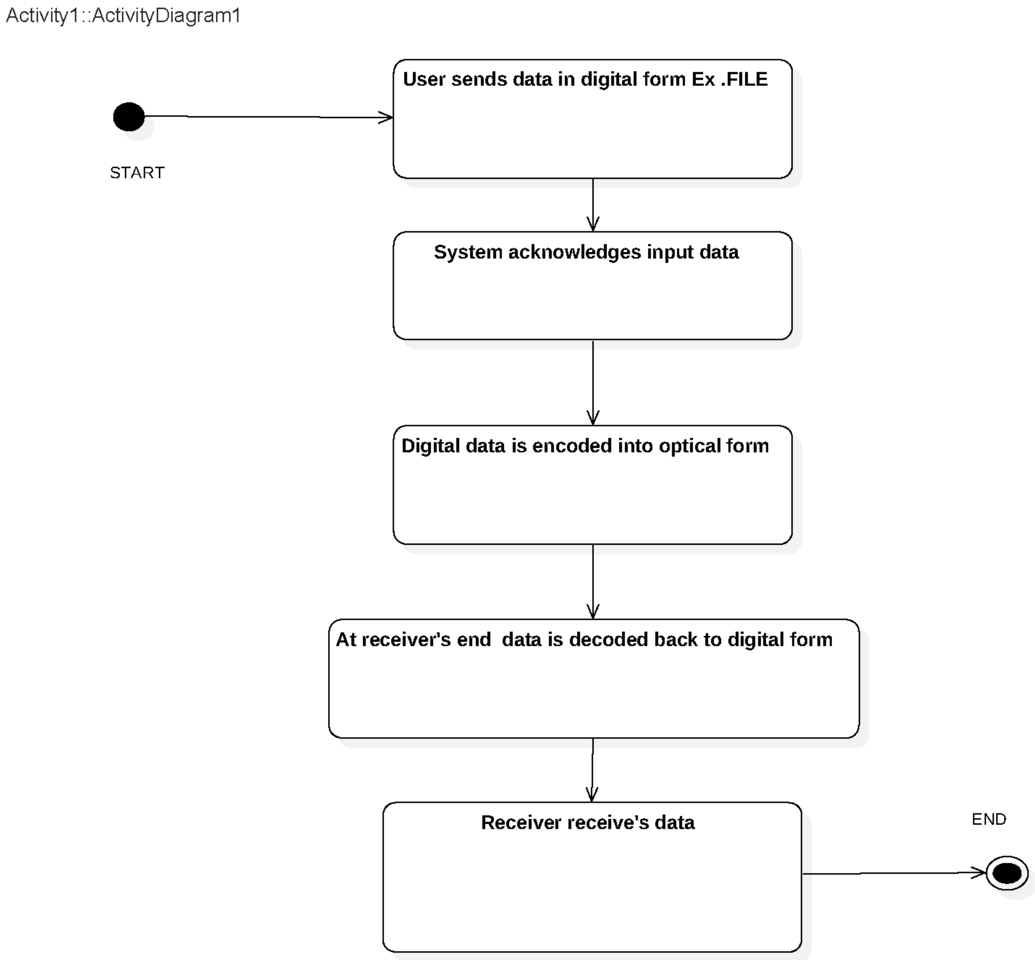


Figure B.5: Activity Diagram

B.2 Theoretical test cases

Sr. No.	Test case	Test scenario	Expected outcome
1	String data transfer	Data across both ends is cross checked	Consistent data transfer
2	Multimedia file transfer	Files at both ends are verified	File integrity maintained
3	Line of sight	Transmitter and receiver are not in a line of sight	Connection failure
4	Obstruction	Transmission light beam is obstructed	Incomplete transmission
5	Encrypted data transfer	Decrypted file at receiver end is verified	Successful verification implies secure transmission else data is tampered

Table B.1: Theoretical test cases

ANNEXURE C

PROJECT PLANNER AND PROGRESS REPORT

C.1 Gantt Chart

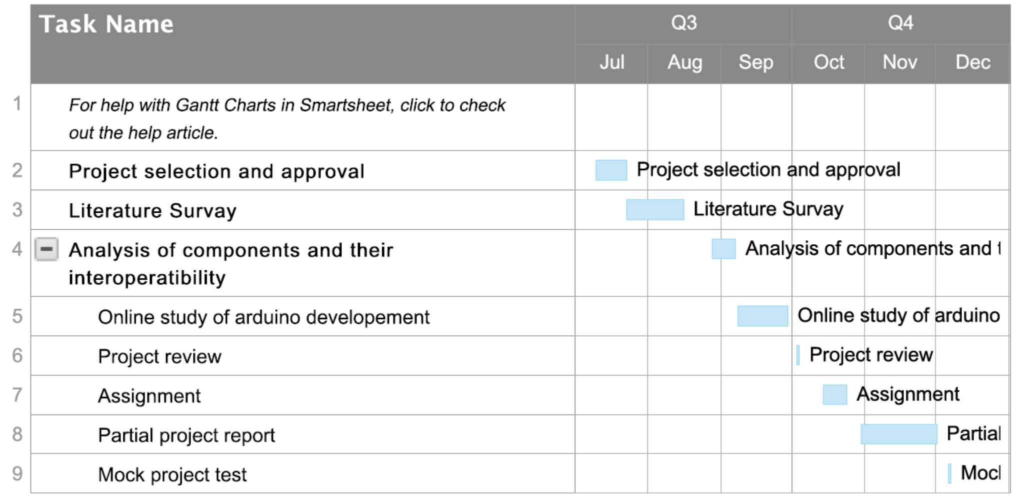


Figure C.1: Gantt chart (semester 1)

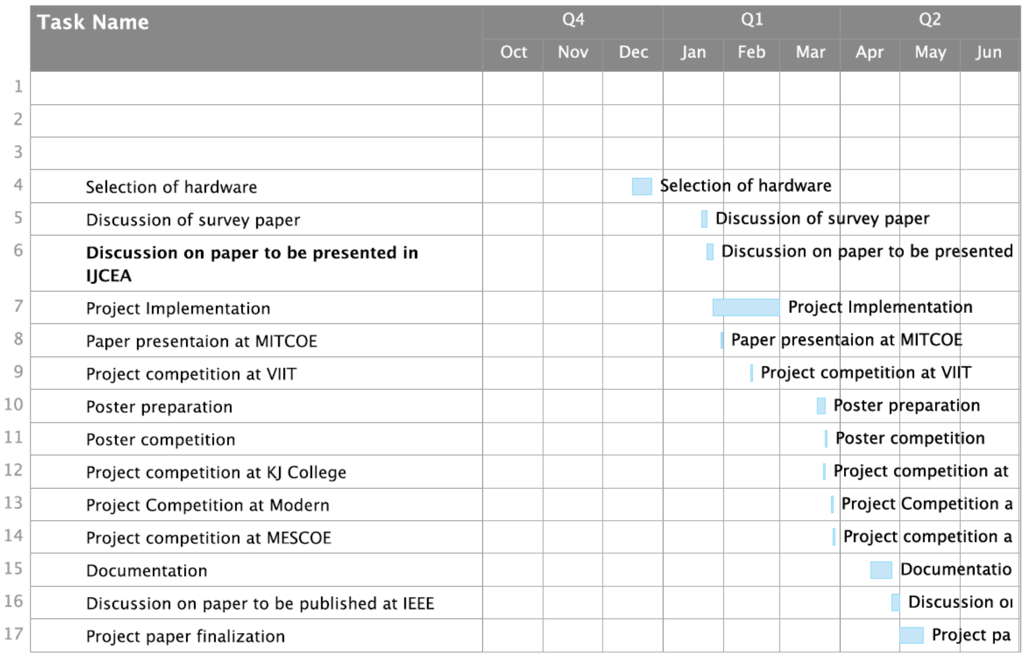


Figure C.2: Gantt chart (semester 2)

ANNEXURE D

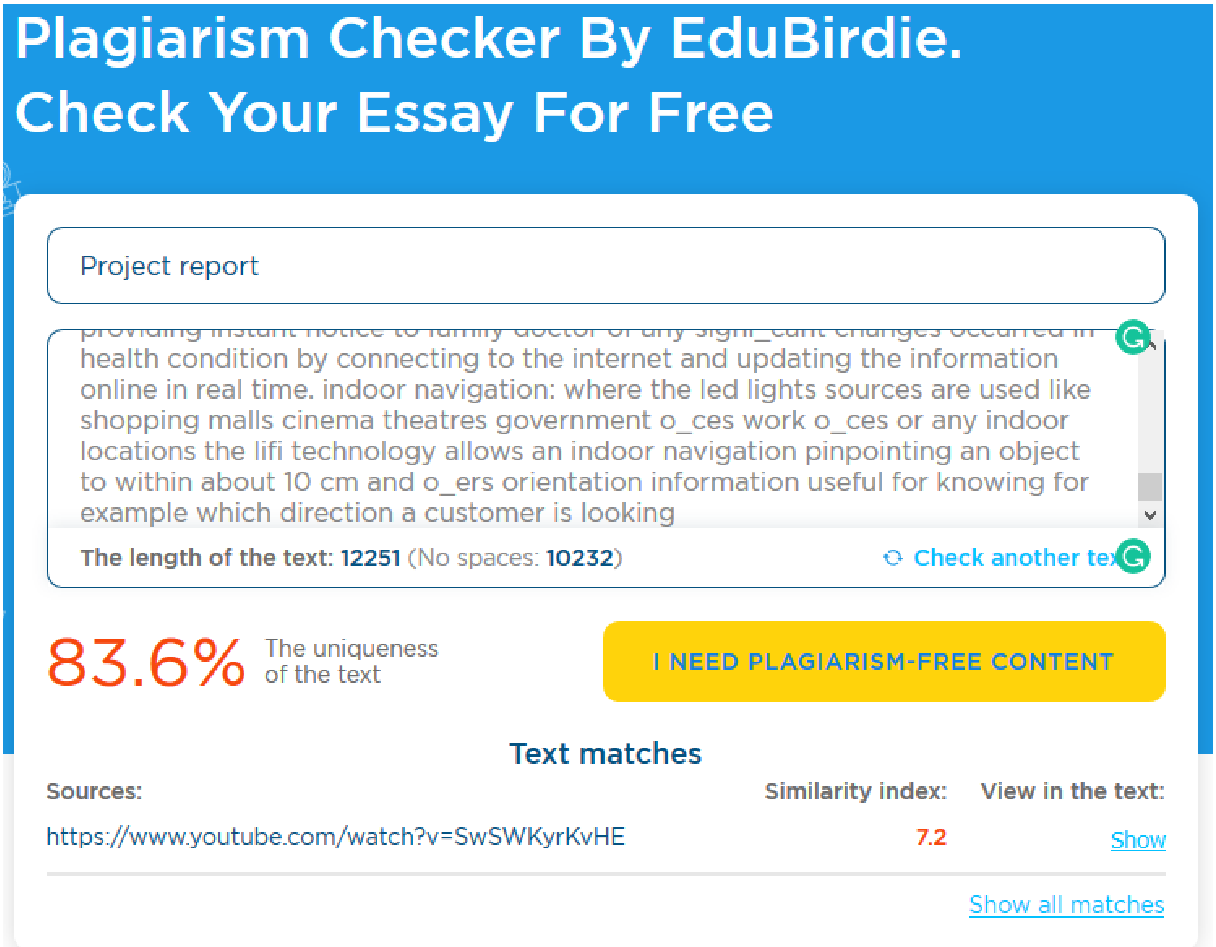
REVIEWERS COMMENTS OF PAPER SUBMITTED

1. Paper Title: "PHOTON: high speed data transmission using light"
2. Name of the Conference/Journal where paper submitted : IJCEA
3. Paper accepted/rejected : Accepted
4. Review comments by reviewer : None
5. Corrective actions if any : None

1. Paper Title: "A new approch to wireless data transmission using visible light"
2. Name of the Conference/Journal where paper submitted : ICCUBEA
3. Paper accepted/rejected : Submitted
4. Review comments by reviewer : None
5. Corrective actions if any : None

ANNEXURE E

PLAGIARISM REPORT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health condition by connecting to the internet and updating the information online in real time. indoor navigation: where the led lights sources are used like shopping malls cinema theatres government o_ces work o_ces or any indoor locations the lifi technology allows an indoor navigation pinpointing an object to within about 10 cm and o_ers orientation information useful for knowing for example which direction a customer is looking
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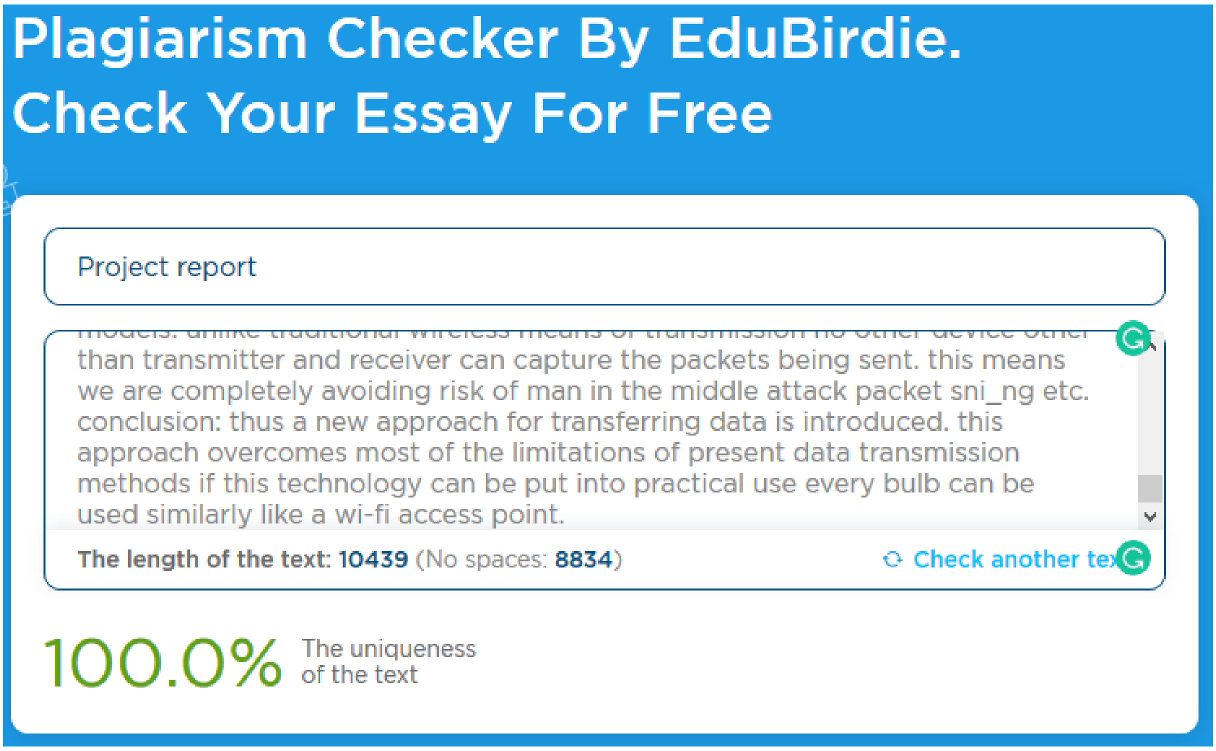
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Project report
than transmitter and receiver can capture the packets being sent. this means
we are completely avoiding risk of man in the middle attack packet sni_ng etc.
conclusion: thus a new approach for transferring data is introduced. this
approach overcomes most of the limitations of present data transmission
methods if this technology can be put into practical use every bulb can be
used similarly like a wi-fi access point.
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ANNEXURE F

TERM-II PROJECT LABORATORY ASSIGNMENTS

1. **Review of design and necessary corrective actions taking into consideration the feedback report of Term I assessment, and other competitions/conferences participated**

   - **Review Parameters**

Parameters	Marks (10)
Significance/Application	8
Innovation and Research	8
Domain Knowledge	8
Technical Knowledge	9
Scope and Feasibility	10
Project Design	9

   - **Reviews to be considered**
     - Speed enhancements required
     - Data accuracy improvement
   - **Corrective measures**
     - Speed was considerably increased by using PC(python) for Data modulation/demodulation.
     - Data accuracy was improved by modifying the encoding scheme to more reliable one.
   - **Competitions participated**
     - VIIT Vishwacon Project Competition
     - MESCOE SHODH Project Competition
     - KJ COE Gravity Project Competition
     - MODERN College of engineering Project Competition
     - MIT Poster Competition

2. **Project workstation selection, installations along with setup and installation report preparations.**

   Installation of Arduino IDE and Python
   Arduino IDE and Python needs to be installed at the client's side to use communicate to arduino through computer.

   (a) Download the arduino IDE application from site:https://www.arduino.cc/en/Main/Software

   (b) Install the arduino IDE with driver.

   (c) Download Python desktop installer from site:https://www.python.org/downloads/

   (d) Install the Python.

   (e) Initially,we need to set up proper connections with arduino uno. This includes selecting correct COM port, connectiong the arduino board to PC on USB port

   (f) Upload the code for transmitter and receiver to respective arduino boards

   (g) Application can be uninstalled by going to Settings-¿System Applications- ¿¿¿¿ Select app and click Uninstall.

3. **Programming of the project functions, interfaces and GUI (if any) as per 1 st Term term-work submission using corrective actions recommended in Term-I assessment of Term-work.**

Basic Functions :

1. Transmitter Side

setup() : The setup() function is called when a sketch starts. It is used to initialize variables, pin modes, start using libraries, etc. The setup() function will only run once, after each powerup or reset of the Arduino board.

begin() : It is used for setting the data rate (baud) for serial data transmission

loop() : It loops consecutively, allowing the program to change and respond.It is used to actively control the Arduino board.

available() : Checks whether the serial input is available.It is used for communication between the Arduino board and a computer or other devices.

readString() : It reads string from serial input.

encodeMsg(String msg) : It is used for encoding message into binary form.

String intToBin(int num): It is used for converting the integer representation into string format.

sendtoLED(String out) : It controls the to control the operation of led by specifying appropriate delays

2. Receiver Side

setup() : The setup() function is called when a sketch starts. It is used to initialize variables, pin modes, start using libraries, etc. The setup() function will only run once, after each powerup or reset of the Arduino board.

loop() : It loops consecutively, allowing the program to change and respond.It is used to actively control the Arduino board.

analogRead() : It is used to collect data from a sensor connected to one of the Arduino analog pins.

delay() : It accepts a single integer as an argument. This number represents the time in milliseconds the program has to wait until moving on to the next line of code.In our system, it is used to provide appropriate delays for sending 0 and 1 through led.

regdigit() :It registers the digit as 0 or 1 depending on sensor value and corresponding delay.

concat() : It is used for appending parameters to already existing string.

println() : It prints the data on console.

Additional Functions :

replace() : It returns a copy of the string where all occurrences of a substring is replaced with another substring.

format() : It reads the type of arguments passed to it and formats it according to the format codes defined in the string.

write() : It is used to write the data to port where arduino is connected

strip() : It is used to remove all the leading and trailing spaces from a string.

encode() : It is used for encoding data in specific format like utf-8.

decode() : It is used for decoding data from specific format.

4. **Test tool selection and testing of various test cases for the project performed and generate various testing result charts, graphs etc. including reliability testing.**

   (a) **Test tool selection**
   Manual testing is done as and when required

   (b) **Test Cases and Test Results**

   - **Unit Testing**
     Unit testing is the testing of an individual unit or group of related units. It falls under the class of white box testing. It is often done by the programmer to test that the unit he/she has implemented is producing expected output against given input.
     - Photo-Diode
     - LED
     - LCD Display
     - Arduino

Test ID	Component Tested	Expected Results	Actual Results
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2	LED	Accurate strobing	Desired strobing accuracy achieved
3	LCD Display	Display correct data	Correct data is displayed
4	Arduino	Proper working	All functionality tested and work properly

Table F.1: Unit Testing

- **Functional Testing**
  Functional testing is the testing to ensure that the specified functionality required in the system requirements works. It falls under the class of black box testing.
  - Data Transmission
  - Data Reception

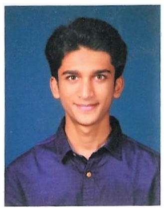
Test ID	Component Tested	Expected Results	Actual Results
1	Data Transmission	Proper encoding of data into light	Data encoded accurately
2	Data reception	Conversion of light pattern into Data	Light pattern successfully converted into original data

Table F.2: Functionality Testing

- **System Testing**
  System testing is the testing to ensure that by putting the software in different environments (e.g. Operating Systems) it still works. System testing is done with full system implementation and environment. It falls under the class of black box testing.
  - Operations in unfavourable conditions(dusty, windy and rainy)
  - Operations in light interference environment

ANNEXURE G

INFORMATION OF PROJECT GROUP MEMBERS



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8. Paper Published :
   1."PHOTON: HIGH SPEED DATA TRANSMISSION USING LIGHT", IJCEA, Volume XII, Special Issue, March 18

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8. Paper Published :
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