Li-Fi Aided Under Water Communication

Project report submitted in partial fulfillment
of the requirements of B-Tech Project for the degree of

Bachelor of Technology
in
Communication and Computer Engineering

by

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CERTIFICATE

This is to certify that the project entitled Li-Fi Aided Under Water Communication, submitted by Anubhuti Jain(16UEC019), Jyoti Kumari(16UEC052) and Shrutika Bansal(16UEC064) in partial fulfillment of the requirement of B-Tech Project for the degree in Bachelor of Technology (B. Tech), is a bonafide record of work carried out by him at the Department of Electronics and Communication Engineering, The LNM Institute of Information Technology, Jaipur, (Rajasthan) India, during the academic session 2018-2019 under my supervision and guidance and the same has not been submitted elsewhere for award of any other degree. In my opinion, this report is of standard required for the submission of B-Tech Project.

Dr. Nikhil Sharma

Date

Adviser: Name of B-Tech Project Supervisor

Dedicated to our Family and Friends.

Acknowledgments

This report would not have been possible without the constant guidance and nurturing provided by our Mentor and guide Dr. Nikhil Sharma. We are grateful to Dr. Divyang Rawal for his constant support. We also acknowledged the support provided by all the Lab Staff, specially Dharmpal Yadav Sir.

Abstract

Underwater Wireless communication can be carried out using radio frequency (RF), acoustics and optical waves. Compared to its bandwidth limited acoustic and RF counterparts, underwater optical wireless communications (UOWCs) can support higher data rates at low latency levels. RF is rendered unusable due to high attenuation and large antennas. In this scenario effective underwater communication has always been a challenge which poses many difficulties especially to scuba divers and underwater exploration. We propose to implement an Underwater Optical Wireless Communication Network using Visible Light Communication (VLC) Technology for the purpose of providing effective communication means for divers along with Sensor Nodes for monitoring the marine environment and the diver for effective real time danger warnings.

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Chapter *1*

Introduction

1.1 The Area of Work

Communication has been an integral part of the human evolution. It's most important aspect being the medium of communication. Communication means have now evolved to be fast, over long distances and convenient. This has largely being possible by use of Radio Frequencies to transmit data over long distances and instantaneously. But now in this age of data explosion and consumption the spectrum provided by RF is dwindling and is insufficient to cater to the next revolution of 5G and IoT. In view of the above it is essential to explore the possibilities opened by Visible Light Communication. The area of work dealt with in this project Light Fidelity which is an application of VLC. The proposed project is to implement a basic prototype of LiFi under water[1A][3].

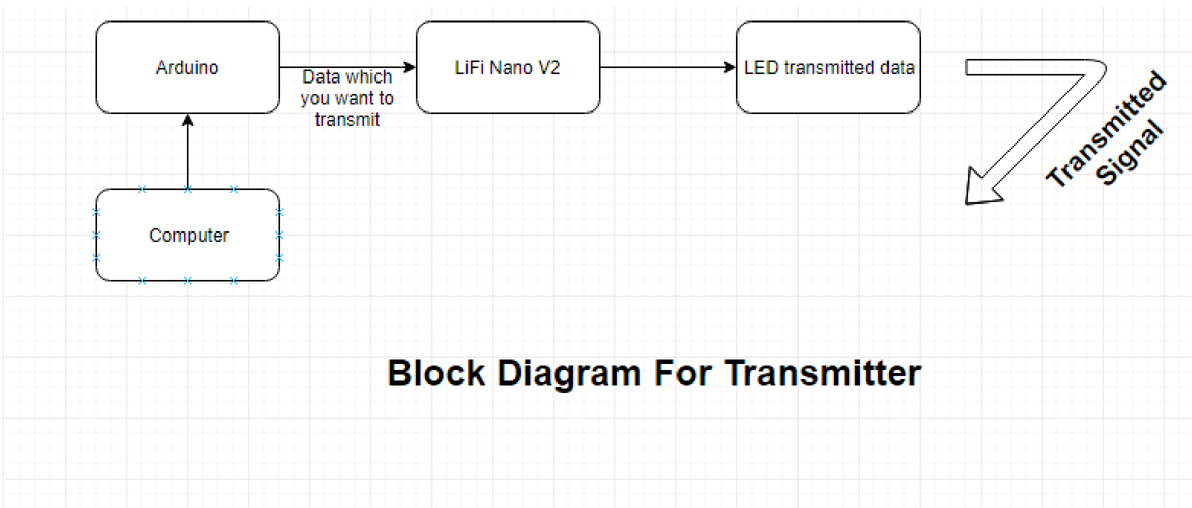
1.2 Problem Addressed

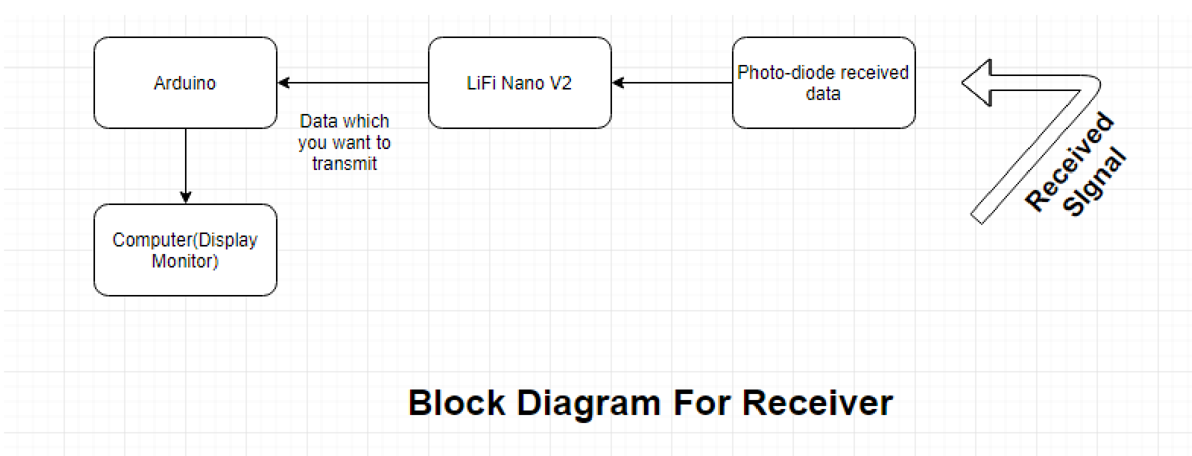
As referred to in the area of interest; the surge in demand for data has posed a number of challenges which need to be overcome. The challenges include:

1. Diminishing RF Spectrum
2. Capacity Crunch
3. Interference
4. Security
5. Energy Efficiency

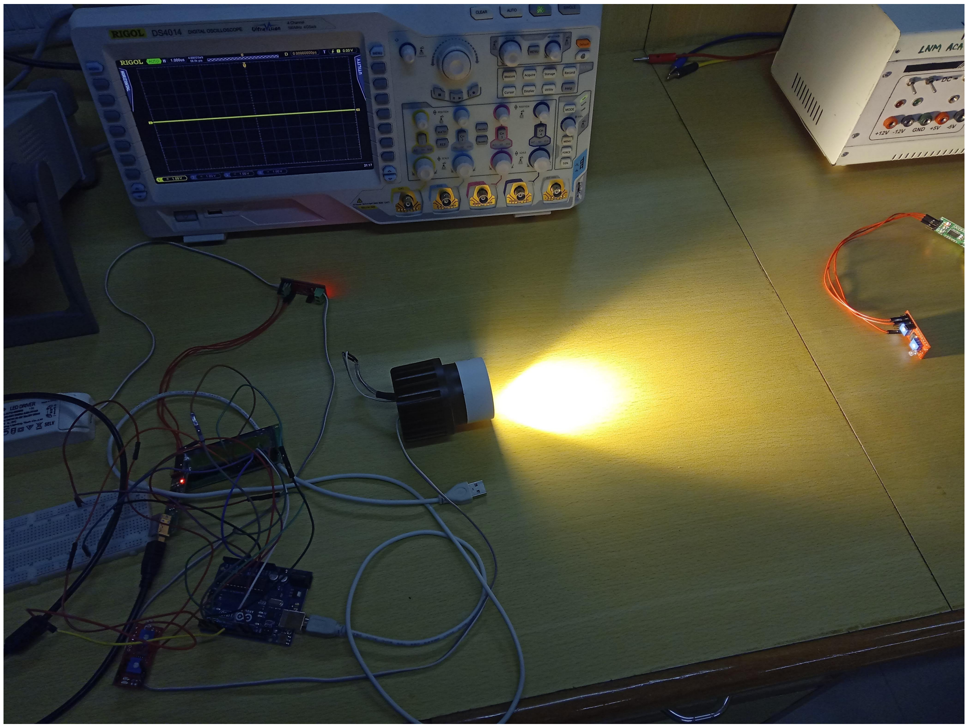
VLC has inert tendencies to overcome these challenges and can be used in collaboration with RF to deliver optimum data transmission under water. One specific application is LiFi which makes use of LEDs to transmit data. This report aims to implement a basic LiFi design and help further an understanding so as to spur development to overcome the above challenges[1B].

1.3 Block Diagram

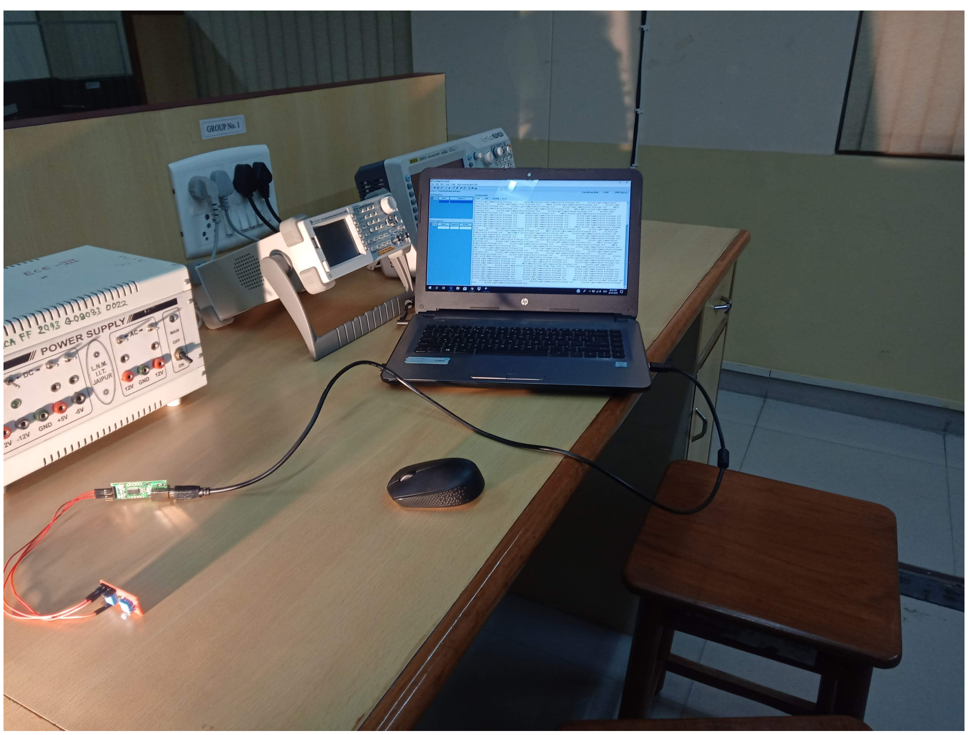




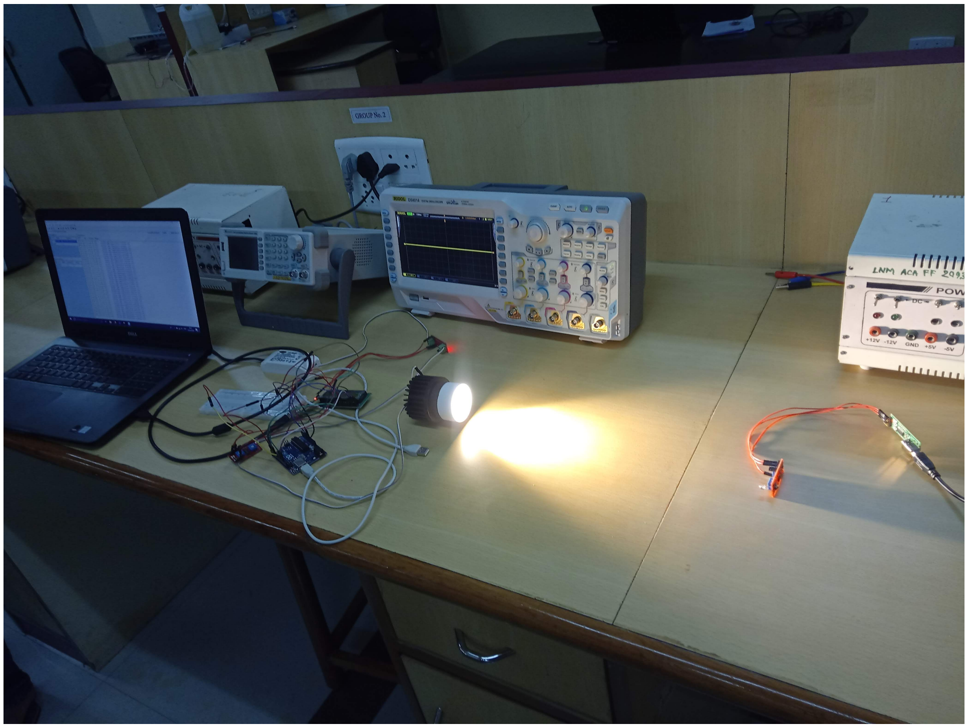
1.4 Establish Setup



Transmitter Side



Receiver Side



Complete Setup

Chapter *2*

Literature Survey

2.0.1 Introduction

In aerial and terrestrial applications, radio and satellite communications provide adequate speed and range. Underwater environments, on the other hand, have a much greater challenge in achieving wireless communication, while at the same time requiring wireless communication even more. Since humans are limited in their ability to work underwater, remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) have been in service since the 1950s to perform underwater tasks, such as collecting data and retrieving items. Operation of these vehicles is challenging, but as oil resources are found further offshore, ROVs and AUVs are required to go deeper and stay deployed longer in order to perform critical tasks. One such task is monitoring a deep sea oil well - sending tethered ROV's thousands of meters below the surface in order to conduct surveys is expensive and time-consuming! It costs on the order of 100,000 dollars a day to operate an ROV, which can take two hours to dive to the bottom at 3000 meters. Wireless data transfer is required to provide the cost-saving benefits of stationing an AUV at a wellhead. The wireless communication method must be able to support data rates high enough to upload video and other sensor data.[2]
Present underwater communication systems involve the transmission of information in the form of sound or electromagnetic (EM) waves. Since radio waves cannot be used underwater because these waves are strongly absorbed by seawater within feet of their transmission and this renders it unusable underwater. There is a need for a robust and reliable communication system which will not be affected severely due to thermal and chemical changes in water's composition.
Through this project, we will present a solution to the need for low-power, cost-effective, high- speed wireless communication.

2.0.2 Advantages over RF communication

Radio waves are not good for underwater communication as they get absorbed in water, but light penetrates through water and can be used for underwater communication. The divers for both lightning and data transfer purpose simultaneously can be used the Li-Fi technology. Therefore, it can allow communication from diver to diver, diver to mini-sub, diver to the drilling rig, etc. Modulated LED lights are used for communications between networked devices, while at the same time these lights can be used to accurately identify and track the user.

2.0.3 Applications

Use cases regarding the project:
1. The solution to Underwater Wireless Communication and Sensor Network(UWCSN) opens the door to various uses. The Primary focus of its use will be for the convenience of the Scuba divers since it will provide for a viable communication option and vital details regarding their safety.

2.UWCSN will provide various governmental agencies/ armed forces underwater surveillance capabilities. For example It will be of immense use in Oil Exploration and Oil Rig maintenance and data collection in real time.

3. Merchant Navy will be immensely benefited by UWCSN. Rescue Operation in Mines and Caves will become easier and drastically reduce the time to the operation of the equipment since they are lightweight, portable, low energy devices.

2.0.4 Challenges

If Li-Fi is to become widespread, a number of challenges pertaining to its commercialization must be addressed. In particular, the drive toward an industry standard, possible market penetration and applications must be considered. Being a relatively modern technology, there are, of course, many challenges that Li-Fi systems are currently facing. Apart from the inherent non-linearity of the LED and limits of LED bandwidth, aspects such as signal modulation, power delivery to the transceiver, and multiple access pose difficulties for the immediate proliferation of Li-Fi. However, since such technical challenges have already been conquered in RF through decades of research, Li-Fi is well equipped to go along a similar, only much-accelerated, path. Implementation of the same underwater is really challenging task as the range of transmission is expected to be really low. Further, the prototype would face a lot of attenuation also underwater. Making it real-time system is also challenging. Furthermore, while the current abundance and maturity of RF communications may impede the commercialization and standardization of Li-Fi technologies, there is no doubt that underwater Li-Fi communication will be needed in future communications.[3][4]

Chapter *3*

Proposed Work

3.1 Working

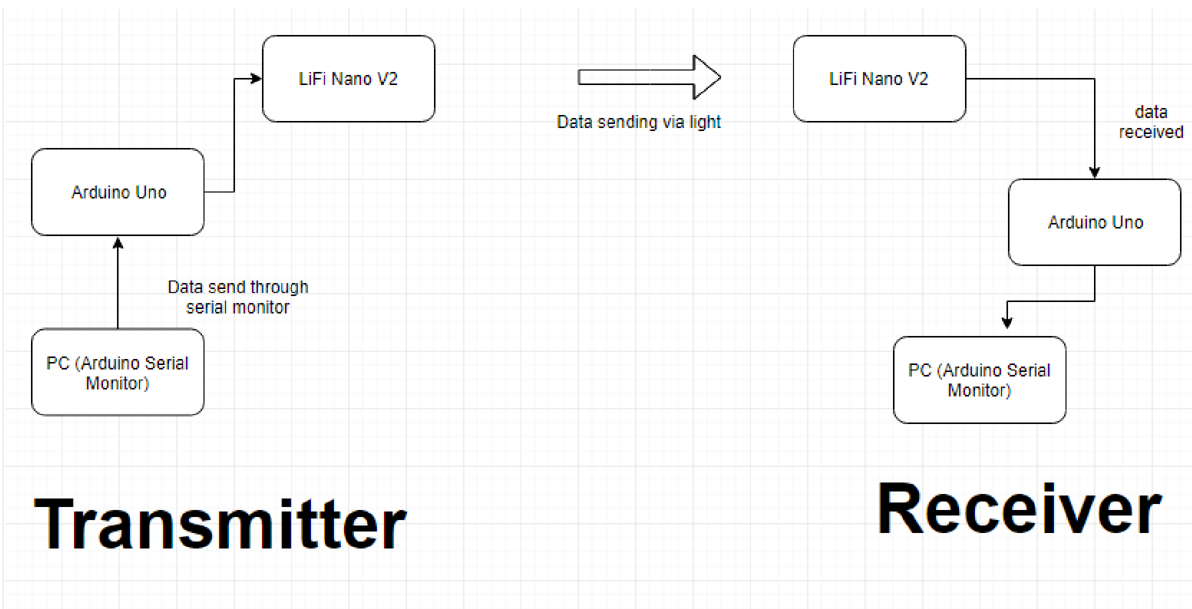
Technology Used: Visible Light Communication(VLC), Sensor Networking, IoT; The setup will be under water consisting of a transmitter-receiver pair with one node as transmitter and another as receiver. Transmitter section will consist of a high powered LED and receiver will have a photo-diode detector. Different sensors will be used to acquire critical information like temperature, heartbeat and pressure which will be transmitted using VLC to the receiver which can be further transmitted as per the requirement.

3.1.1 Serial Data Transmission

Aim was to transmit data (numerical and char) from serial monitor of transmitter side to that of receiver side. Working:-
Model used for implementation of above task is LiFi Nano V2.
Are able to transfer small streams of data from the transmitter to the receiver after setting up a connection which is shown in diagram shown below:

3.1.1.1 Components required

1) 2 x Arduino Uno R3 Board
2) 1 x LiFi Nano V2
3) 2 x Laptops with Processing software



Block Diagram for Serial Data Transmission

3.1.2 Transmission of Sensor Data

Aim is to transmit data received from temperature sensor from serial monitor of transmitter side to that of receiver side and plot real time graph of the same.

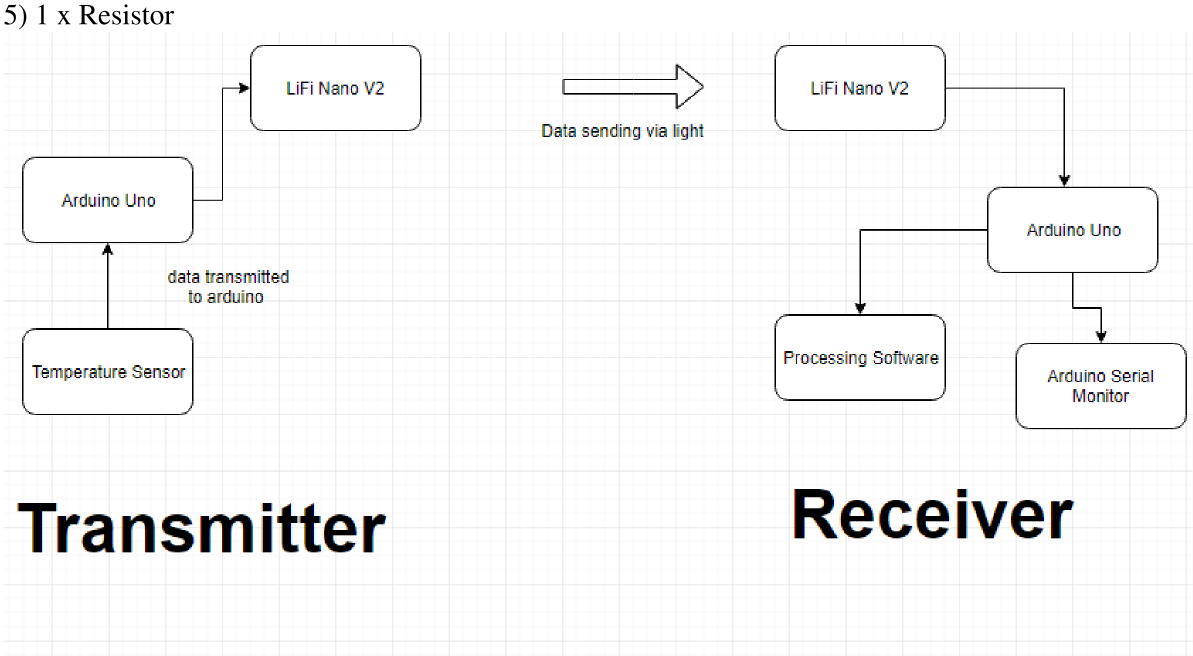
Working:-

Temperature Sensor is connected to the Arduino and the received temperature values are Transmitted via the LiFi Transmitter and the values received at the receiver of the LiFi Module aer then plotted by using Arduino and Processing.

Software used to plot graph-Processing.

3.1.2.1 Components required

1) 2 x Arduino Uno R3 Board
2) 1 x LiFi Nano V2
3) 2 x Laptops with Processing software
4) 1 x Temprature sensor(LM35)
5) 1 x Resistor



Block Diagram for Transmission of Sensor Data

3.1.3 Image Transmission

Aim is to transmit data image from transmitter side to receiver side.

Working:-

1.Model used for implementation of above task is LiFi Nano V2.

2.Once the connections are set up, first convert image file into its corresponding numerical matrix.

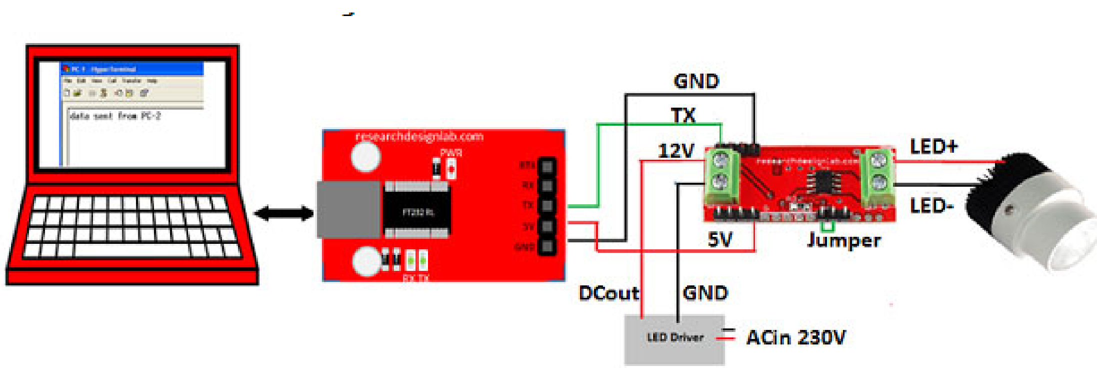
3.DCT of image values are then calculated (MATLAB) and stored in text file.

4.Then transmit the text file to receiver side. The received data is stored in text file through processing tool.

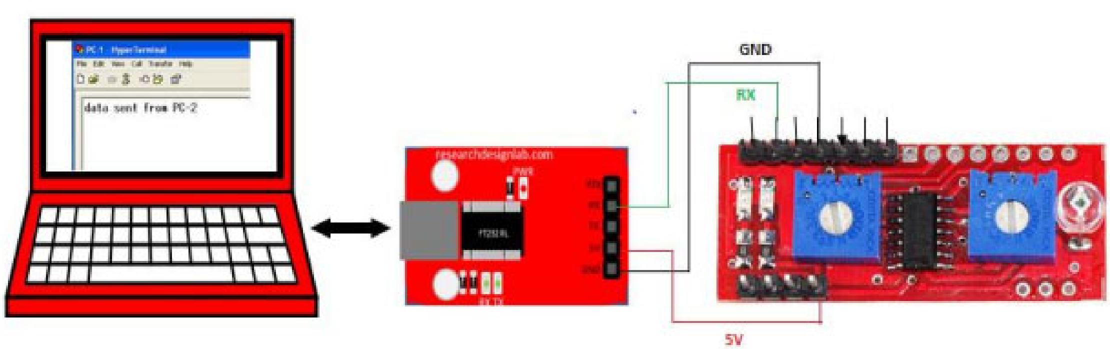
5.IDCT of data values was taken to reconstruct back the actual transmitted image .

3.1.3.1 Components required

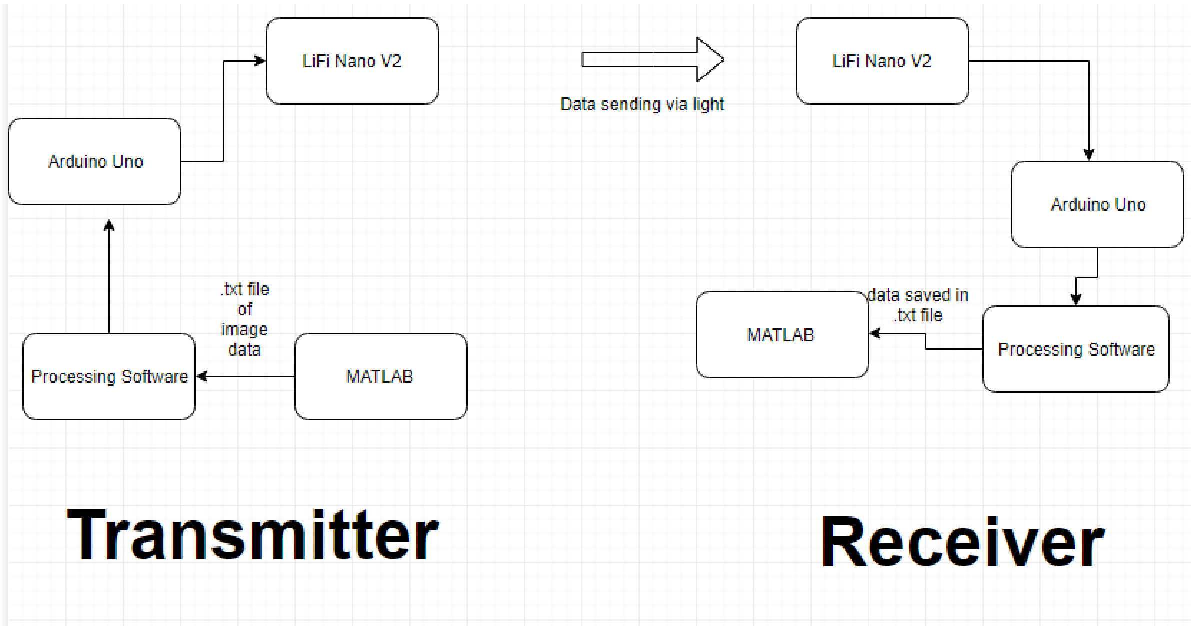
1) 2 x Arduino Uno R3 Board
2) 1 x LiFi Nano V2
3) 2 x Laptops with Processing software



LiFi Nano V2 transmitter



LiFi Nano V2 receiver



Block Diagram for Image Transmission.

3.2 Problem faced:-

3.2.1 Image Transmission

1.Retrieval of exact data values is a challenge with around 60-70% values obtained are correct values.
2.Synchronisation of data at the receiver is difficult.
3.Calibration of the Module for the appropriate distance proved to be a challenge.

3.3 Steps taken to overcome the problems

1.Introducing an end marker for each data transmission.
2.Making use of guard bits at start of transmission.
3.Making use of guard bits at end of transmission.
4.Padding the data segment with white spaces to prevent synchronization loss.

Chapter *4*

Simulation and Results

4.1 Code for Serial Data Communication

4.1.1 Transmitter Code

```
void setup() {
  Serial.begin(38400);
}

void loop() {
  if(Serial.available()>0)
  {
    Serial.write(Serial.read());
  }
}
```

4.1.2 Receiver Code

```
void setup()
{
  Serial.begin(38400);
}

void loop() {
  if(Serial.available()>0)
  {
    Serial.write(Serial.read());
  }
}
```

4.2 Code for Sensor Data Transmission

4.2.1 Transmitter Code

```
int inPin = A1; // analog pin
#include <stdlib.h>
int radix=10;
char val[3];
char cel[3];
char fah[3];
void setup()
{
 Serial.begin(38400);
}

void loop()
{
            float value = 100;//analogRead(inPin);
            float millivolts = (value / 1024) * 5000;
            int celsius = (int)millivolts / 10; // sensor output is 10mV per degree Celsius
            int fahrenheit=(celsius * 9)/ 5 + 32;
            //Serial.write(itoa(value,val,radix));
            //Serial.write(" > ");
            Serial.write(itoa(celsius,cel,radix));
            //Serial.write(celsius);
            //Serial.write("degrees Celsius, ");
            //Serial.write( itoa(fahrenheit,fah,radix ));// converts to fahrenheit

            delay(1500); // wait for one second
}
```

4.2.2 Receiver Code

```
void setup()
{
  Serial.begin(38400);
}

void loop() {
  if(Serial.available()>0)
  {
    Serial.write(Serial.read());
  }
}
```

4.3 Code for Image Data Transmission

4.3.1 Transmitter Code(Arduino)

```
const byte numChars = 70;
char receivedChars[numChars];   // an array to store the received data
boolean newData = false;

void setup() {
    Serial.begin(38400);
}
void loop() {
    recvWithEndMarker();
    showNewData();
}

void recvWithEndMarker() {
    static byte ndx = 0;
    char endMarker = '\n';
    char rc;

    while (Serial.available() > 0 && newData == false) {
        rc = Serial.read();

        if (rc != endMarker) {
            receivedChars[ndx] = rc;
            ndx++;
            if (ndx >= numChars) {
                ndx = numChars - 1;
            }
        }
        else {
            receivedChars[ndx] = '\0'; // terminate the string
```

```
                receivedChars[ndx] = '\0'; // terminate the string
                ndx = 0;
                newData = true;
            }
        }
    }

    void showNewData() {
        if (newData == true) {
            //Serial.write("This just in ... ");
            Serial.write(receivedChars);
            newData = false;
        }
    }
```

4.3.2 Transmitter Code(Processing Software)

```
import processing.serial.*;
printArray(Serial.list());
Serial myPort;
myPort = new Serial( this, Serial.list()[0], 38400 );
String line="          "+"000000000000000000000000000000000000000000000000000000000000000000000000000000000000000"+"          "+System.lineSeparator(); /
myPort.write(line);
println(line);
String[] lines=loadStrings("datafile_1.txt");
int k=0;
int c=0;
for (int i = 0 ; i <3240; i=i+90)
{
  String sub=lines[0].substring(i,i+90);
  sub="          "+ sub +"      " +  System.lineSeparator();  // Padding the data at start and end. Also attaching an end marker.
  myPort.write(sub);
  print(sub);
  c=i;;
 //delay(1);
}
String sub=lines[0].substring(c,c+75);
sub="      "+ sub +"      " +  System.lineSeparator();
print(sub);
sub="      "+ sub +"      " +  System.lineSeparator();
String end ="          "+"0000000000000000000000000000000000000000000000000000000000000000000000000000000000"+"          "+System.lineSeparator(); // Gu
myPort.write(end);
print(end);
print(lines.length);
myPort.stop();
```

4.3.3 Receiver Code(Arduino)

```
const byte numChars = 70;
char receivedChars[numChars];   // an array to store the received data
boolean newData = false;

void setup()
{
    Serial.begin(38400);
}

void loop()
{
    recvWithEndMarker();
    showNewData();
}

void recvWithEndMarker()
{
    static byte ndx = 0;
    char endMarker = '\0';
    char rc;
    int i=3;
    //memset(&receivedChars[0],0,sizeof(receivedChars));
    while (Serial.available() > 0 && newData == false ) {
        rc = Serial.read();
        if (rc != endMarker)
        {
            receivedChars[ndx] = rc;
            ndx++;
            if (ndx >= numChars)
```

```
    char rc;
    int i=3;
    //memset(&receivedChars[0],0,sizeof(receivedChars));
    while (Serial.available() > 0 && newData == false ) {
        rc = Serial.read();
        if (rc != endMarker)
        {
            receivedChars[ndx] = rc;
            ndx++;
            if (ndx >= numChars)
            {
                ndx = numChars - 1;
            }
        }
        else
        {
            ndx = 0;
            newData = true;
        }
    }
}

void showNewData() {
    if (newData == true)
    {
        Serial.println(receivedChars);
        memset(&receivedChars[0],0,sizeof(receivedChars));
        newData = false;
    }
```

4.3.4 Receiver Code(Processing Software)

```
import processing.serial.*;
Serial mySerial;
PrintWriter output;
void setup() { // Setup the connection to the Serial Port.
   mySerial = new Serial( this, Serial.list()[0], 38400 );
   output = createWriter( "data.txt" );
}
void draw() { // Listens on the Serial Port for any incoming character and save it to a text file.
    if (mySerial.available() > 0 ) {
         String value = mySerial.readString();
         if ( value != null ) {
              output.println( value );
         }
    }
}

void keyPressed() {
    output.flush();  // Writes the remaining data to the file
    output.close();  // Finishes the file
    exit();  // Stops the program
}
```

Chapter 5

Conclusions and Future Work

5.0.1 Conclusion

The shortcomings of RF communication in terms of spectral and bandwidth motivates the research into visible light communication. Now with the surge in LED usage has thrown open the door for many VLC potential. One of which is LiFi capability. This report has sought to verify its usage in underwater communication scenario as a possible data transmission means which has been successfully collaborated by the results.Hence a proof of concept that Visible Light Communication can be used for underwater communication has being demonstrated. Certain issues faced in the prototype are interference, noise and a lack of set protocol to meet the networking requirements. These issues are been dealt with by various research groups to make it a promising technology for the future. The results conclusively proves the versatility of LiFi as an enabling technology for the future deployment of IoT and VLC as the mode of last mile connection in 5G. VLC can also lead to Smart Grid enhancements.

5.0.2 Scope of further work

The proposed work for the future can be broadly divided into 4 categories:

1. Wireless Underwater Optical Communication System Acoustic modems have long been the default wireless communication method for underwater applications due to their long range, the need for high speed communication for underwater applications due to their long range, the need for high speed communication has prompted the exploration of non-acoustic methods that have previously been overlooked due to their distance limitations. The proposed work aims to setup an optical communication using LED's so as the improve the speed over moderate distances with the use of low power and low complexity communication systems. The proposed work looks to use super bright blue LED based transmitter system and a blue enhanced photo-diode based receiver system with the goal of transmitting data at rates of 1 Mbps over distances of at least 10 meters. This work will be beneficial to assess the effectiveness of Visible Light Communication as an alternative in underwater communication. Its applications include but not limited to Unmanned Vehicle communications with the oil rigs, data trans-

fer at high rates. It will make use a Blue light LED's, LED driver and photo-diode to accomplish the task.

2. Underwater Sensor Network Making use of the above technology, transmit relevant sensor data for further action.

3. Further refinements and enhancements in terms of speed and operable distance.

Chapter *6*

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