Wireless Communication System Using Li-Fi Technology

A project report submitted in partial fulfillment of the requirement for the award of Degree of Bachelor of Science in Electrical & Electronic Engineering

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DECLARATION

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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CERTIFICATION

This is to certify that this project entitled "**Wireless communication system using Li-Fi technology**" is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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ABSTRACT

Li-Fi stands for Light Fidelity. 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.

Our system focuses on unidirectional transmission, allowing for efficient one-way communication of text data from a transmitter to a receiver. Li-Fi offers an alternative to traditional Wi-Fi by using light waves for wireless communication. Li-Fi is an advanced technology that allows transmitting data using optical communication such as visible light. Li-Fi data can travel through the LED light and then interpreted on the receiver side using any light-sensitive device like photodiode. Key advantages of our proposed system include high data transmission speeds and immunity to radio frequency interference. Further research and development in this area have the potential to unlock new possibilities for high-speed wireless communication in various domains.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Li-Fi (Light Fidelity) is a high speed, wireless communication using visible light. It falls under the category of optical wireless communications. Data transmission takes place through LED (Light Emitting Diode) bulbs whose intensity varies. Based on this variation, communication occurs digitally. This technology has broad applications where the use of Wi-Fi (Wireless Fidelity) is limited or banned. It also takes out the adverse health effects of using electromagnetic waves. Unless the light is seen, data cannot be hacked, and so data transmission is secure. Data transmission is typically in terms of Gigabytes per second. [1] The usage of light as a means to transmit data has been coined Li-Fi (Light - Fidelity) by Harald Hass at the University of Edinburgh[2]. The high-speed communication technology is similar to Wi-Fi but is faster, allowing users to send and receive more data in less time. By merely swapping incandescent bulbs with LEDs - which have electronic properties - Li-Fi could bring Internet gain access to more areas and could revolutionize the telecoms industry. Recently, wireless technology has bloomed to a great extent where we require wireless technology to transmit many data every day. Nowadays, wireless communications have become important in the communication process. The primary way of wireless data transmission is by using electromagnetic waves, i.e., radio waves. However, radio waves can support less bandwidth because of compact spectrum availability and intrusion. Solution to this is data transmission using Visible Light Communication (VLC) [1]. Wi-Fi deals with wireless coverage within premises, whereas Li-Fi is perfect for high compactness wireless data coverage in a defined area and for mitigating radio interference issues. Li-Fi focuses on transmitting multimedia data between two terminals using LEDs. Communication between two terminals in the 21st century is vital and occurs every day. Li-Fi plays an essential role in communication as discussed earlier which uses light for data transmission rather than radio waves used in wireless communication.

The velocity of data transmission was about 10Mbps, though it is aimed to improve up to 100 Mbps by 2022 [3]. Li-Fi can be achieved by fitting a small microchip to every possible illumination device thereby, combining two basic functionalities: illumination and wireless data transmission. By doing this, the four essential problems (i.e., capacity, cost, efficiency, and security) faced in wireless communication these days would be solved. Thus, in the future, there would not be only 14 billion light bulbs, but 14 billion Li-Fi APs (Access Points) deployed worldwide -- for a cleaner, a greener and even brighter future.

1.2 Objective:

In the course of design and installation of a Wireless communication system using Li-Fi technology, the following criteria are set to fulfill its objectives:

- Develop a robust encoding and modulation technique to efficiently transmit text data using Li-Fi technology. The project must not be too costly and be affordable to all.
- Design and construct a transmitter module capable of encoding text data into light sig nals for transmission.
- Implement error correction and encryption mechanisms to ensure reliable and secure t ransmission of text data over the Li-Fi channel

1.3 Methodology

- Creating an idea for Design and construction of Wireless communication system usin g Li-Fi technology. And designing a block diagram & circuit diagram to know which components need to construct it.
- Collecting all the components and programming the micro-controller to control the w hole system.
- Setting up all the components in a PVC board. Lastly, assembling all the blocks to run the system for checking purposes.

CHAPTER 2
LIRERATURE REVIEW

2.1 Introduction

This chapter is arranged on Literature Review. Here's a look at some of last year's literature, like our project. By reading them, we can overcome the mistakes of the previous project and make a more effective project.

2.2 Literature Review

The Li-Fi technology are being developed to improve the data rate, efficiency and low power consumption. Li-Fi is a bidirectional network system and provides a substantially similar experience as Wi-Fi to the user. As we move toward the future, the connectivity demands are going to increase exponentially. [6] To cater to these demands we need higher spectral capacity network. With, Li-Fi we can utilize the spectrum 10,000 times greater than that of radio frequency. Li-Fi is now providing unprecedented data and bandwidth.

It is a category of optical wireless communications, includes infra-red and ultra-violet communication as well as visible light [3]. However, Li-Fi is unique in that the same light energy used for illumination may also be used for communication. The working of Li-Fi is simple but powerful. When an LED light bulb is supplied with constant current stream of photons are emitted from the bulb which is seen as illumination. LED bulbs are semiconductor devices, which means the current, and therefore the illumination can be modulated at extremely high speeds which can be detected by the photodetector.

Using this technique, transmission of high-speed information can be done through a LED bulb. Li-Fi uses direct modulation methods that are similar to the low-cost infrared devices like remote controls. Also, LED light bulbs can have very large data rates as the LED bulbs have very high intensities. [2] A good data density reduces the need to share the bandwidth with other users hence, improving the user experience. The achievable data density by the Li-Fi is 10,000 times greater than the Wi-Fi. Hence, this provides more data per square meter [4]. The Li-Fi communication system can work even under the

sunlight as the modulated light rays can still be detected. Since the system works on the detection of rapid changing light intensity and not the slow varying levels which can be caused by disruptions due to the sunlight. As light waves in Li-Fi are heavily modulated, the sun just adds a constant light which can be easily filtered out by the receiver.

2.3 Li-Fi Technology

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.

2.4 Summary

We try to do this project by reading the above literature, and we have been able to make our project successfully by reducing the mistakes of last year's project.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter we describe our project block diagram, circuit diagram, project working principle and final project view.

3.2 Block Diagram

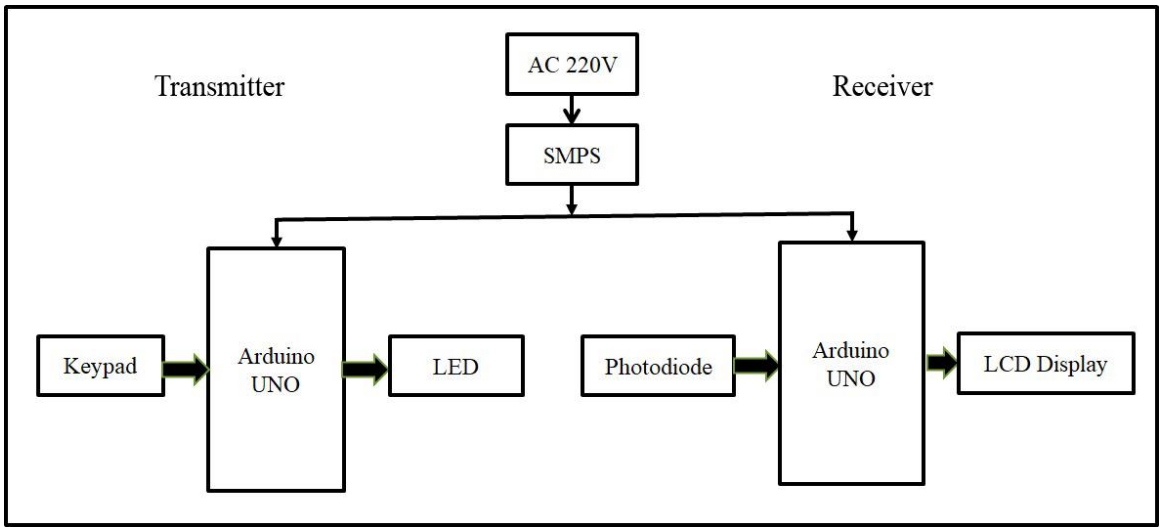


Figure 3.1: Block Diagram

The block diagram consists of two parts, which are transmitter and receiver. At the heart of the transmitter is an Arduino board, serving as the central processing unit. An LED light is connected to the Arduino board. The Arduino modulates the intensity of the LED to encode the data into light pulses. A Matrix Keypad is connected to the Arduino as the data source. This data is processed by the Arduino and encoded into light pulses for transmission. On the receiver side, another Arduino board is utilized. This Arduino board is responsible for receiving the transmitted light signals and decoding them back into text data. A photodiode is connected to the receiver Arduino which detects variations in light intensity caused by the transmitted light pulses. The LCD display module is connected to the receiver Arduino as the output medium for the received data. The decoded data is displayed on the LCD screen in a human-readable format.

An SMPS is used as a power source. It converts 220V AC to 5V DC and provides constant DC power throughout the system.

3.3 Schematic Diagram

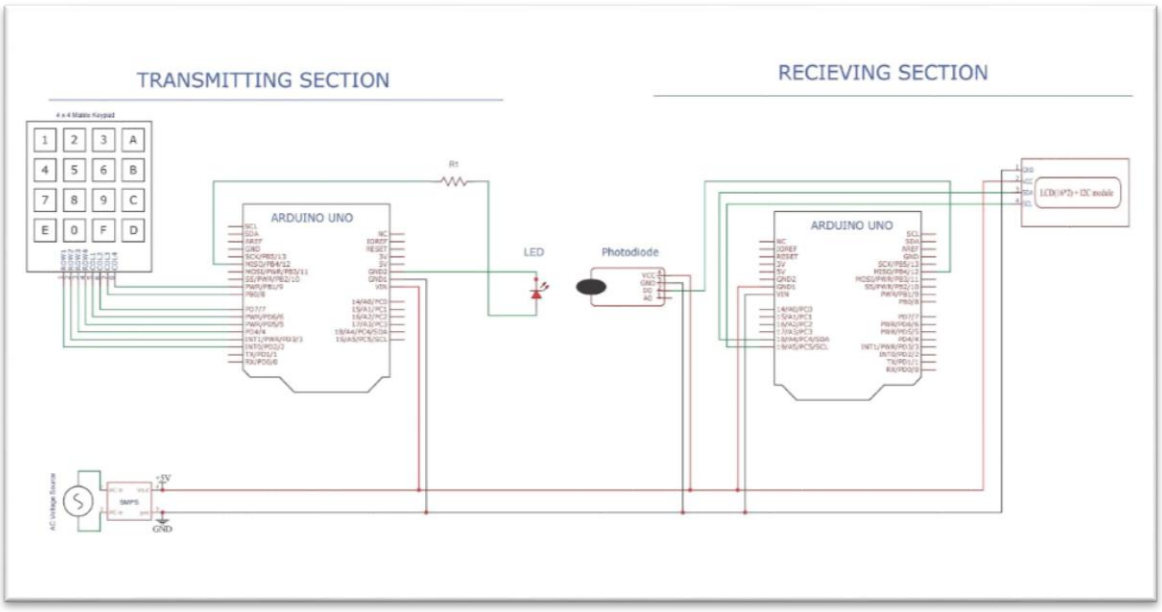


Figure 3.2: Schematic Diagram

3.4 Working Principle

There are two parts in our Li-Fi project. These are Receiver and Transmitter. Transmitter and receiver sections contain Arduino which is programmed using Arduino IDE software.

In the transmitter section, the keypad is used as input here. That means we'll be selecting the text to be transmitted using the keypad. Then the information is processed by the Microcontroller (Arduino UNO). Arduino converts the information into binary pulses which can be fed to an LED source for transmission. Then these data are fed to LED light which sends the visible light pulses to the receiver side.

In the receiver section, the photodiode receives the visible light pulses from the transmitter side and converts it into interpretable electrical pulses. Arduino receives this pulse and reconstruct it into actual data and displays it on LCD display. Then the user can read the transmitted text data.

3.5 Project Prototype Image:

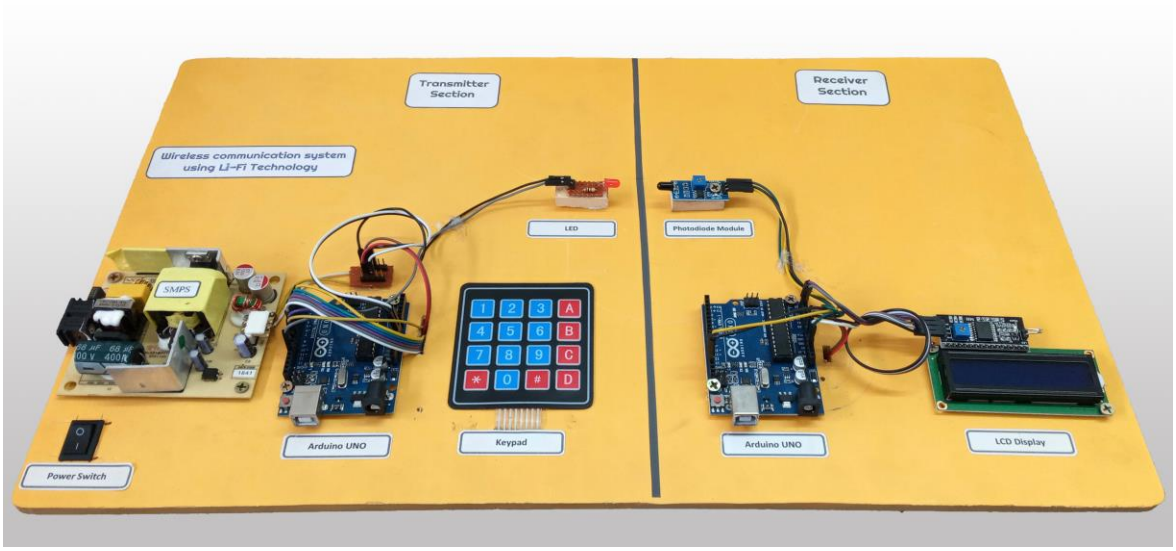


Figure 3.3: Project Prototype Image

3.6 Components List:

- ✓ Arduino UNO
- ✓ Matrix Keypad 4*4
- ✓ LED
- ✓ Photodiode Module
- ✓ LCD Display 16*2
- ✓ I2C Module
- ✓ SMPS

3.7 Cost Analysis

Sl. No	Articulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	Arduino UNO	ATmega328P	2	750	1500
2	Keypad	4x4 Matrix	1	100	100
3	LED	5 mm	1	10	10
4	Photodiode Module	Distance 2 ~ 30cm	1	120	120
5	LCD Display	16x2	1	250	250
6	I2C Module	PCF8574	1	100	120
7	SMPS	Output: 5V DC	1	300	450
8	Others	PVC Board, Screw, Connecting wire, Resistor, Switch, Power Cable, Vero Board, etc.	-	1000	1000
				Total	**3550/-**

Table 1: Instrument list with Cost

3.8 Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

.



Figure 3.4: Arduino UNO

The word "UNO" means "one" in Italian and was chosen to mark a major redesign of the Arduino hardware and software.[7] The Uno board was the successor of the Duemilanove release and was the 9th version in a series of USB-based Arduino boards.[8] Version 1.0 of the Arduino IDE for the Arduino Uno board has now evolved to newer releases.[4] The ATmega328 on the board comes preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.[3] While the Uno communicates using the original STK500 protocol,[1] it differs from all preceding boards in that it does not use a FTDI USB-to-UART serial chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

USB bus specification has a voltage range of 4.75 to 5.25 volts. The official Uno boards have a USB-B connector, but 3rd party boards may have a miniUSB / microUSB / USB-C connector.5.5mm/2.1mm barrel jack connector. Official Uno boards support 6 to 20 volts, though 7 to 12 volts is recommended. The maximum voltage for 3rd party Uno boards varies between board manufactures because various voltage regulators are used, each having a different maximum input rating. Power into this connector is routed through a series diode before connecting to VIN to protect against accidental reverse voltage situations.

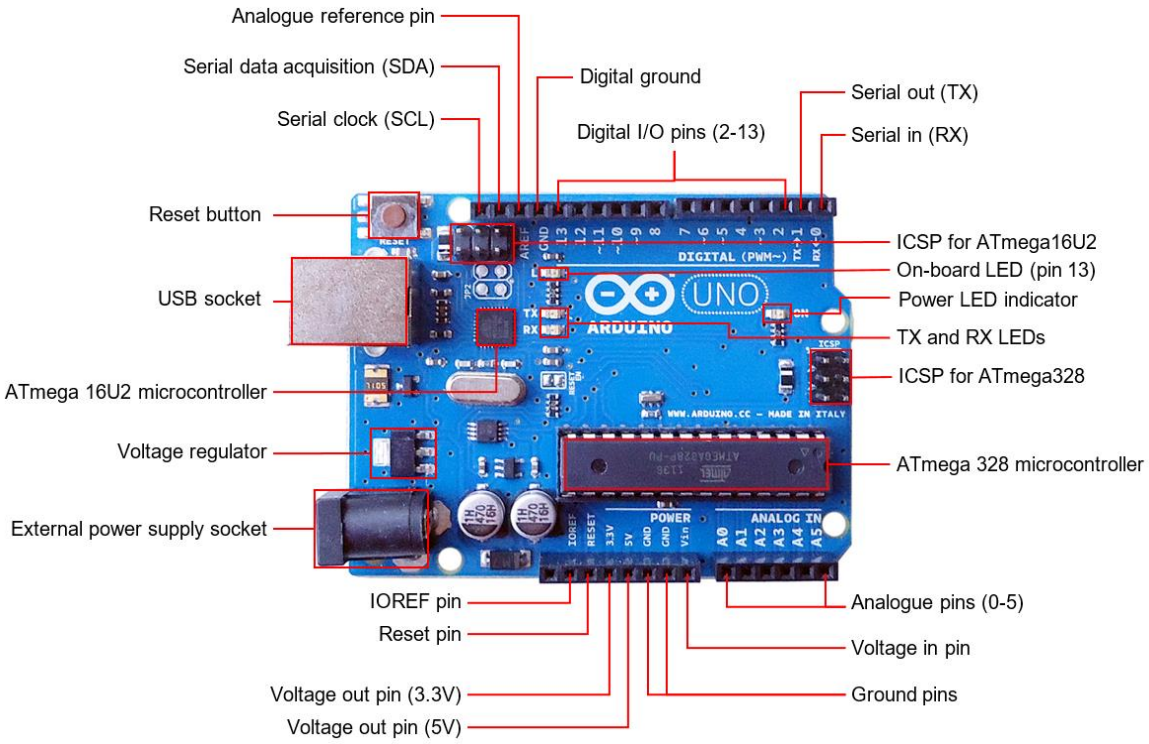


Figure 3.5: Arduino UNO Hardware Description

ATmega328P Microcontroller

- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6 (DIP) or 8 (SMD)
- DC Current per I/O Pin: 40 mA
- Flash Memory: 32 KB
- SRAM: 2 KB
- EEPROM: 1 KB

Digital Pins

In addition to the specific functions listed below, the digital pins on an Arduino board can be used for general purpose input and output via the pinMode(), digitalRead(), and digitalWrite() commands.

Each pin has an internal pull-up resistor which can be turned on and off using digitalWrite() (w/ a value of HIGH or LOW, respectively) when the pin is configured as an input. The maximum current per pin is 40 mA.

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. O n the Arduino Diecimila, these pins are connected to the corresponding pins of the FT DI USB-to-TTL Serial chip. On the Arduino BT, they are connected to the correspond ing pins of the WT11 Bluetooth® module. On the Arduino Mini and LilyPad Arduino , they are intended for use with an external TTL serial module (e.g. the Mini-USB Ad apter).
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a l ow value, a rising or falling edge, or a change in value. See the attachInterrupt() functi on for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() functi on. On boards with an ATmega8, PWM output is available only on pins 9, 10, and 11.
- BT Reset: 7. (Arduino BT-only) Connected to the reset line of the Bluetooth® module
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communicati on, which, although provided by the underlying hardware, is not currently included in the Arduino language.
- LED: 13. On the Diecimila and LilyPad, there is a built-in LED connected to digital p in 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

Analog Pins

In addition to the specific functions listed below, the analog input pins support 10-bit analog-to-digital conversion (ADC) using the analogRead() function. Most of the analog inputs can also be used as digital pins: analog input 0 as digital pin 14 through analog input 5 as digital pin 19. Analog inputs 6 and 7 (present on the Mini and BT) cannot be used as digital pins.

- I2C: 4 (SDA) and 5 (SCL). Support I2C (TWI) communication using the Wire library

Power Pins

- VIN (sometimes labelled "9V"). The input voltage to the Arduino board when it's usin g an external power source (as opposed to 5 volts from the USB connection or other r egulated power source). You can supply voltage through this pin, or, if supplying volt age via the power jack, access it through this pin. Also note that the LilyPad has no VI N pin and accepts only a regulated input.
- 5V. The regulated power supply used to power the microcontroller and other compon ents on the board. This can come either from VIN via an on-board regulator, or be sup plied by USB or another regulated 5V supply.
- 3V3. (Diecimila-only) A 3.3 volt supply generated by the on-board FTDI chip.
- GND. Ground pins.

Other Pins

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

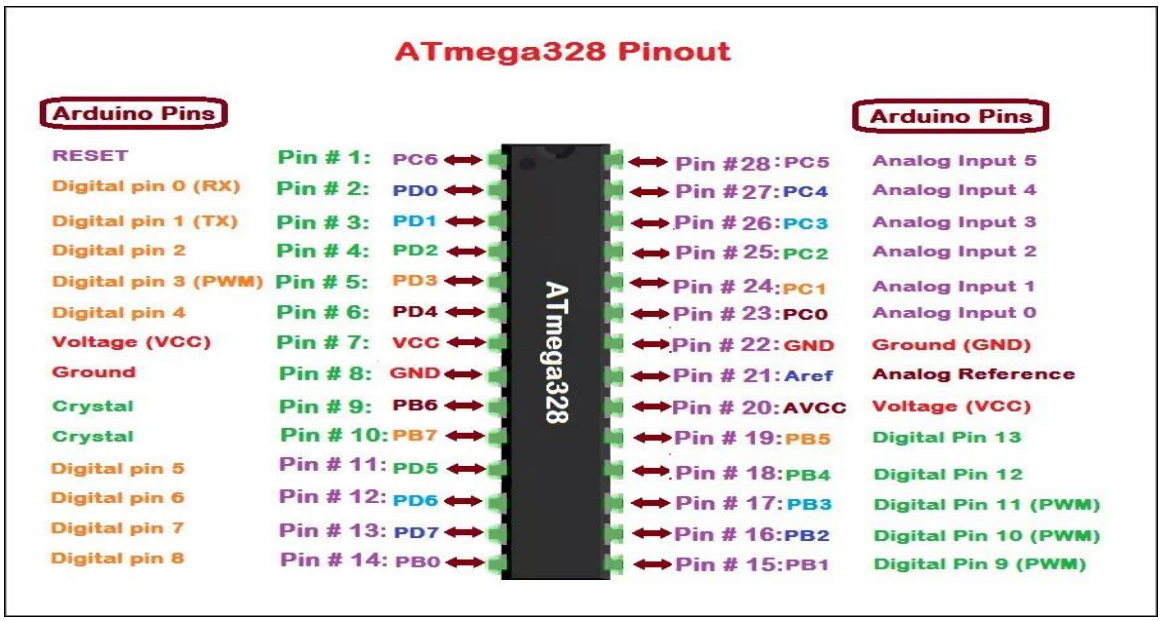


Figure 3.6: ATmega328 Pinout

3.9 Keypad

Matrix Keyboard is a kind of keyboard whose layout is like a matrix and it's used as a peripheral equipment of MCU. The structure of matrix keyboard is more complex than that of other common keyboards, and the condition is similar to that of the recognition. The column line is connected with the anode of the power supply through resistors and let the I/O port of MCU connected with the row line work as an output terminal. The I/O port connected with the column line will be the input.

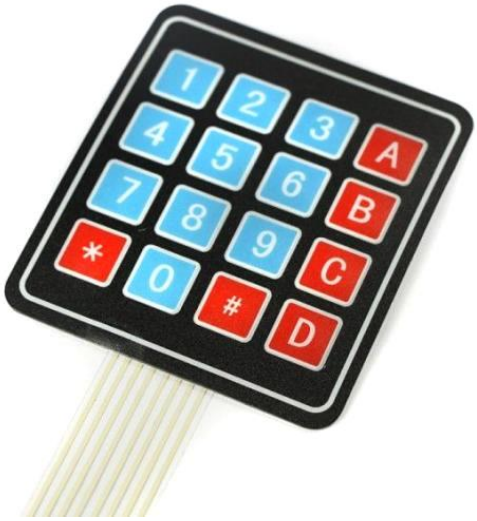


Figure 3.7: 4*4 Matrix Keypad

During the circuit design, there is much more need of external input. It will consume much IO source if we control a button separately, we have the matrix keyboard. The most common types are 4*4 and 8*8. Among them, the type 4*4 is even more common than 8*8.

On a keyboard, if there are too many buttons, we will arrange them into the form of matrix to decrease the using of the I/O port. In the internal structure of the matrix keyboard, each horizontal line and each vertical line are not connected directly at the intersection, but at the button. Therefore, a port (eg. P1) can form 4*4=16 buttons, and the number is twice as much as that of the button whose port cable is connected with keyboard.

Specifications

- Key layout: 4 rows x 4 columns (16 keys total)
- Key Type: Membrane
- Operating voltage: 3V - 5V DC
- Interface: 8 digital pins (4 for rows, 4 for columns)
- Connector: Female 2.54mm Pitch

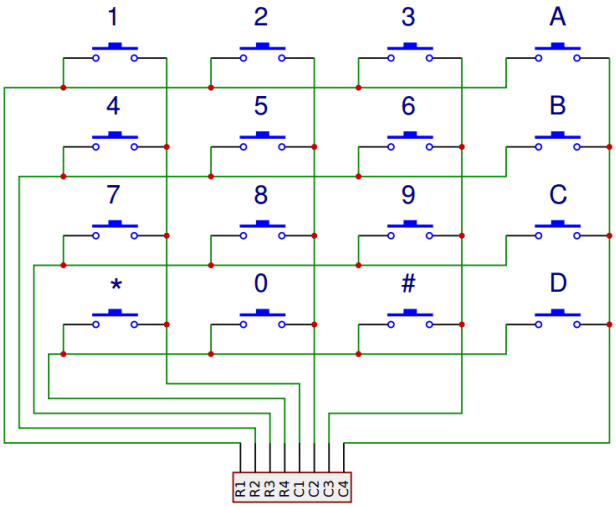


Figure 3.8: Layout of 4*4 Matrix Keypad

Matrix keypads use a combination of four rows and four columns to provide button states to the host device, typically a microcontroller. Underneath each key is a pushbutton, with one end connected to one row, and the other end connected to one column. In order for the microcontroller to determine which button is pressed, it first needs to pull each of the four columns (pins 1-4) either low or high one at a time, and then poll the states of the four rows (pins 5-8). Depending on the states of the columns, the microcontroller can tell which button is pressed.

Features

- Ultra-thin design
- Adhesive backing
- Excellent performance ratio
- Easy interface to any microcontroller

3.10 LED

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device.

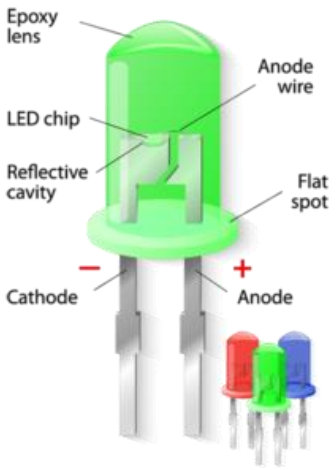


Figure 3.9: LED

Since light is generated within the solid semiconductor material, LEDs are described as solid-state devices. The term solid-state lighting, which also encompasses organic LEDs (OLEDs), distinguishes this lighting technology from other sources that use heated filaments (incandescent and tungsten halogen lamps) or gas discharge (fluorescent lamps).

Inside the semiconductor material of the LED, the electrons and holes are contained within energy bands. The separation of the bands (i.e. the bandgap) determines the energy of the photons (light particles) that are emitted by the LED.

The photon energy determines the wavelength of the emitted light, and hence its color. Different semiconductor materials with different bandgaps produce different colors of light. The precise wavelength (color) can be tuned by altering the composition of the light-emitting, or active, region.

3.11 LCD Display

The LCD (liquid crystal display) screen is an electronic display module and looks for various applications. A 16x2 LCD display is a very basic module and it is very commonly used in various devices and circuits. These modules are preferred over seven sections and many other segments.



Figure 3.10: 16*2 LCD Display

The reasons for having LCD are economic; Easily programmable, special and even custom characters (different in seven sections), there are no restrictions on displaying animations. A 16x2 LCD means it can display 16 characters per line and contains 2 lines. Each character on this LCD is displayed in a 5x7 pixel matrix.

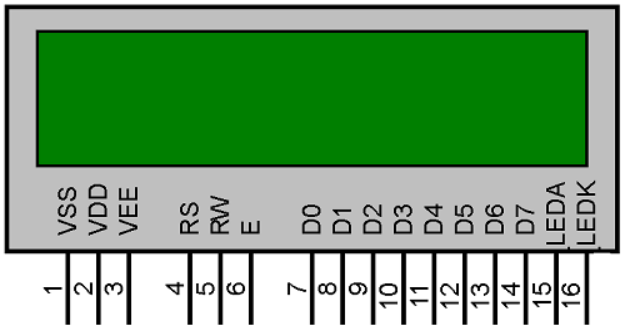


Figure 3.11: Pinout of 16*2 LCD Display

This LCD contains two articles called Command and Data. The command register stores the command instructions on the LCD. The command is a command given to the LCD to perform a predefined task such as starting it, clearing its screen, locating the cursor, controlling the display, etc.

Features

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

3.12 I2C Module

As the pin resources of Arduino controller is limited, controlling an LCD Display could be tedious. Serial to Parallel adapters such as the I2C serial interface adapter module with PCF8574 chip makes the work easy with just two pins. The serial interface adapter can be connected to a 16x2 LCD and provides two signal output pins (SDA and SCL) which can be used to communicate with an MCU. I2C Module has a inbuilt PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display.

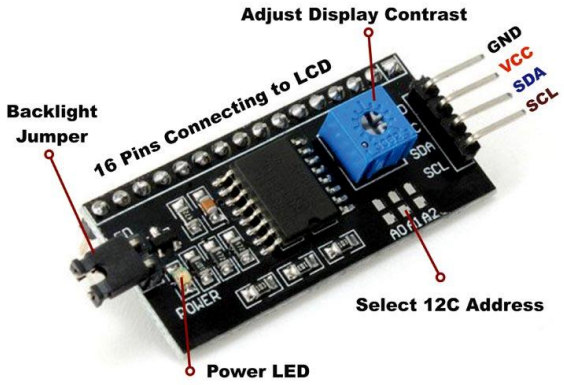


Figure 3.12: I2C Module

Features

- Operating Voltage: 5V
- Backlight and Contrast is adjusted by potentiometer
- Serial I2C control of LCD display using PCF8574
- Come with 2 IIC interface
- Compatible for 16x2 LCD
- This is another great IIC/I2C/TWI/SPI Serial Interface
- With this I2C interface module, able to connect the display via only 2 wires.

3.13 Photodiode Module

The photodiode sensor module is ideal for circuits which are equipped with a microcontroller platform like Arduino. When ambient light intensity does not reach the threshold value, the "DO" port output high lever. When the ambient light intensity exceeds a set threshold, the "DO" output low level.

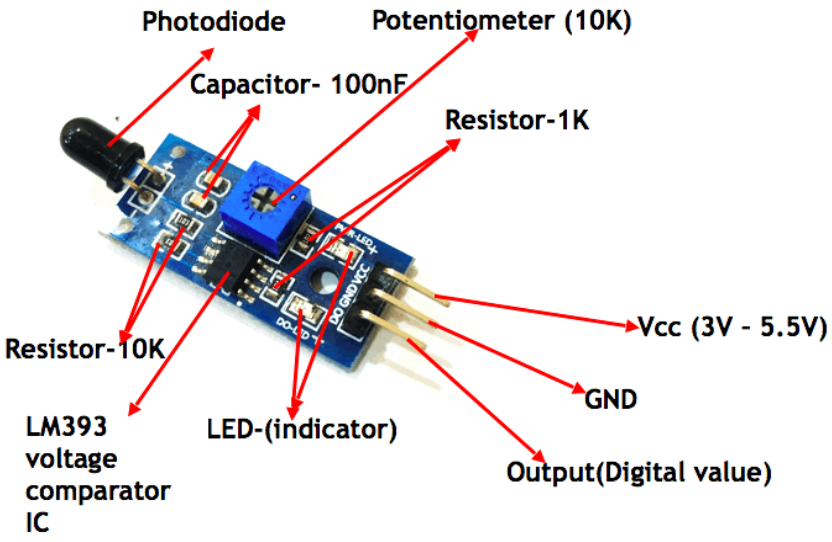


Figure 3.13: Photodiode Module

The photodiode module operates at 3.3V to 5V, and the digital output pin gives out a HIGH or LOW signal depending on the light intensity level. When ambient light intensity does not reach the threshold value, the "D0" port outputs a high level; When the ambient light intensity exceeds a set threshold, the "D0" outputs a low level.

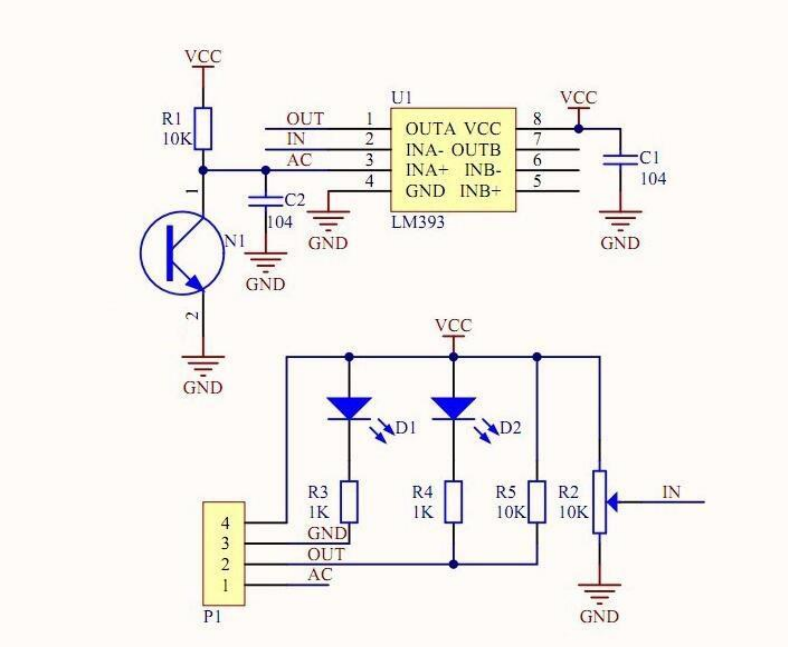


Figure 3.14: Circuit Diagram of Photodiode Module

This module consists of 3 pins that allow it to connect to a microcontroller easily, like Arduino.

- **GND:** Ground pin to connect the sensor to the ground with the microcontroller
- **VCC:** Power pin for 3.3V to 5V operation voltage with the microcontroller
- **D0:** Digital output pin based on a predefined threshold through the potentiometer and the operation voltage of the microcontroller.

Specification

- Operating Voltage: 3.3V – 5V
- Current: > 15mA
- Comparator Chip: LM393
- Sensor Type: YG1006 NPN Phototransistor
- Spectrum Range: 760nm – 1100nm
- Detection Angle: About 60 degrees
- Detection Range: Up to 1m

3.14 SMPS

A switched-mode power supply (SMPS) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power when the switching device is in its non-conduction state. Switching power supplies have high efficiency and are widely used in a variety of electronic equipment, including computers and other sensitive equipment requiring stable and efficient power supply. An SMPS typically converts power from AC source to DC.



Figure 3.15: SMPS

Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter
- Inverter consisting of switching devices such as MOSFETs
- Ferrite Core Transformer
- Output rectifier and filter
- Feedback and control circuit

The input DC supply from a rectifier is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.



Figure 3.16: SMPS Circuit

3.15 Arduino IDE Software

The smart microcontroller unit named as Arduino UNO can be programmed with the Arduino software. There is no any requirement for installing other software rather than Arduino. Firstly, Select "Arduino UNO from the Tools, Board menu (according to the microcontroller board). The IC used named as ATmega328 on the Arduino UNO comes pre burned with a boot loader that allows to upload new code to it without the use of an external hardware program.

Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and programs the microcontroller through the ICSP (In Circuit Serial Programming) header. 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.

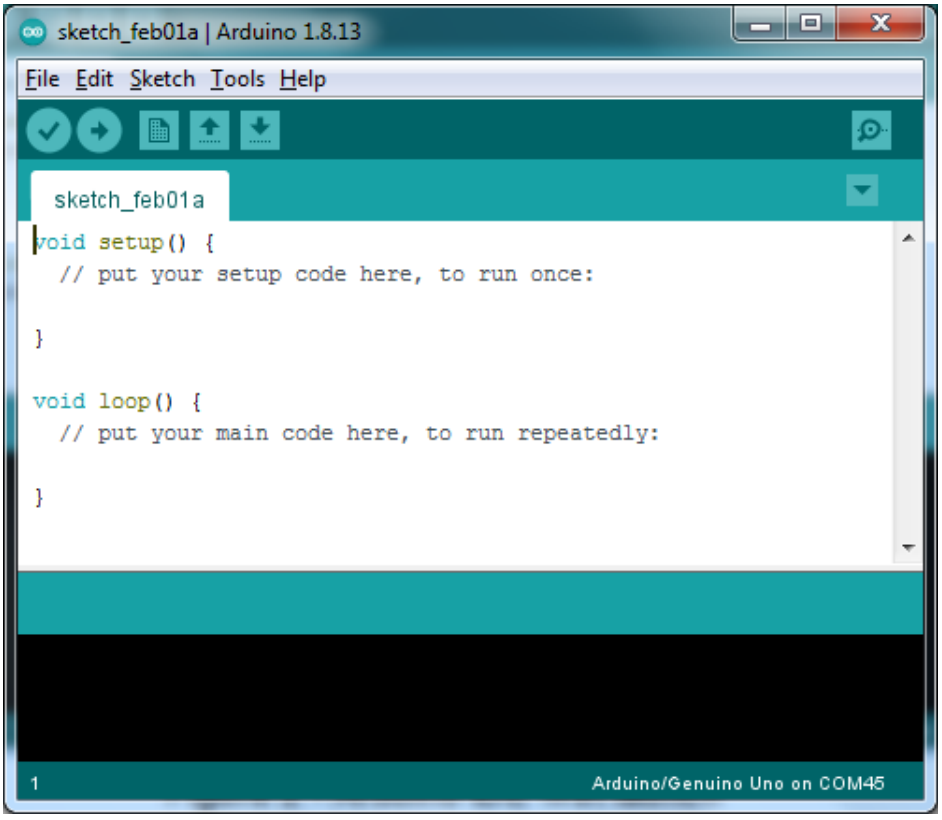


Figure 3.17: Arduino IDE Software Interface

The Arduino UNO is one of the latest smart microcontroller units and has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. 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, an .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 (but not for serial Communication on pins 0 and 1). 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 library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Libc to compile programs, and for uploading the programs it uses avrdude. As the Arduino platform uses Atmel microcontrollers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.

3.16 Easy EDA Software

Easy EDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share-publicly and privately-and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats. Easy EDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription. Registered users can download Gerber files from the tool free of charge; but for a fee, Easy EDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

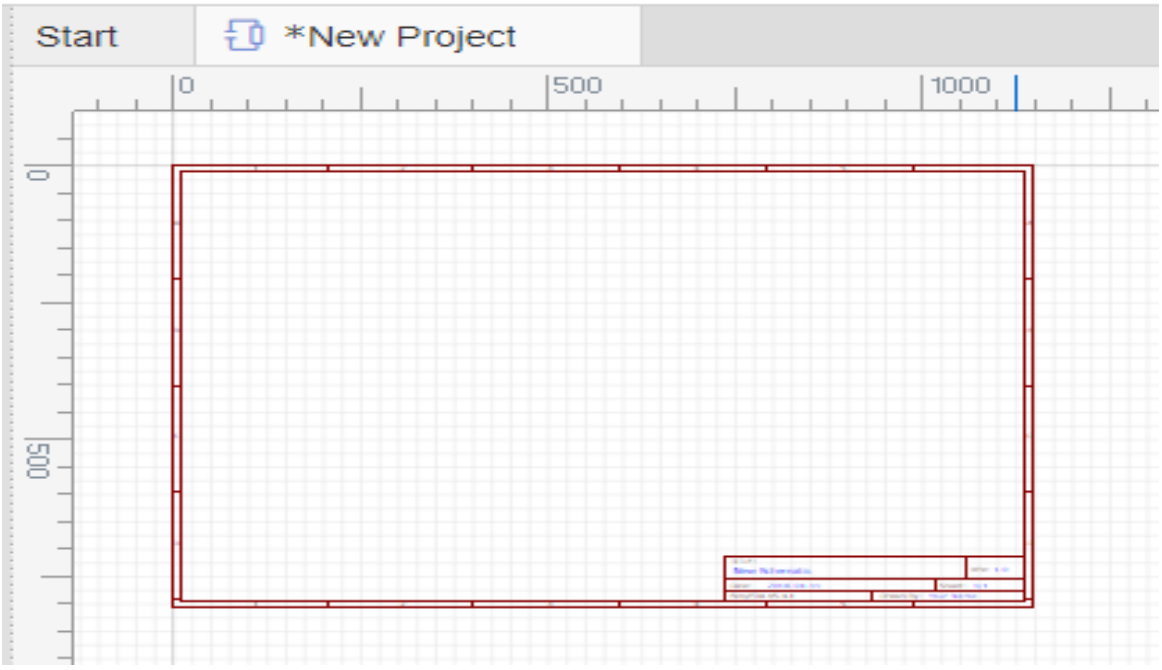


Figure 3.18: Easy EDA Software Interface

CHAPTER 4
DISCUSSION AND APPLICATION

4.1 Discussion

The possibilities are numerous and can be explored further with the Li-Fi technology. If this technology can be put into practical use, every bulb can be used like a Wi-Fi hotspot to transmit wireless data and we will proceed toward a cleaner, greener, safer, and brighter future. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio-based wireless isn't allowed such as aircraft or hospitals. Although we had some difficulty in building this system, due to the perseverance and valuable guidance of the supervisor, we completed this project successfully.

4.2 Applications of Li-Fi

Some of the future applications of Li-Fi could be as follows:

- ***Medical Applications:*** Operation theatres (OTs) do not allow Wi-Fi due to radiation c oncerns. Usage of Wi-Fi at hospitals interferes/blocks the signals for monitoring equip ment. So, it may have hazardous effect to the patient's health, due to improper workin g of medical apparatus. To overcome this and to make OT tech savvy Li-Fi can be use d to access internet and also to control medical equipment. This will be beneficial for conducting robotic surgeries and other automated procedures
- ***Cheaper Internet in Aircrafts:*** The passengers travelling in aircrafts get access to low speed Internet that too at a very high price. Also Wi-Fi is not used because it may int erfere with the navigational systems of the pilots. In aircrafts Li-Fi can be used for dat a transmission. Li-Fi can easily provide high speed Internet via every light source suc h as overhead reading bulb, etc. present inside the airplane.

- ***Underwater applications:*** Underwater ROVs (Remotely Operated Vehicles) operate f rom large cables that supply their power and allow them to receive signals from their pilots above. But the tether used in ROVs is not long enough to allow them to explore larger areas. If their wires were replaced with light — say from a submerged, high-po wered lamp — then they would be much freer to explore. They could also use their he adlamps to communicate with each other, processing data autonomously and sending t heir findings periodically back to the surface. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military unde rwater operations.
- ***Applications in sensitive areas:*** Power plants need fast, inter-connected data systems so that demand, grid integrity and core temperature (in case of nuclear power plants) c an be monitored. The Radio communication interference is considered to be bad for s uch sensitive areas surrounding these power plants. Li-Fi can offer safe, abundant con nectivity for all areas of these sensitive locations. Also, the pressure on a power plant 12 ‘s own reserves (power consumption for Radio communications deployments) will be lessened.
- ***Traffic management:*** In traffic signals Li-Fi can be used to communicate with passin g vehicles (through the LED lights of the cars etc) which can help in managing the tra ffic in a better manner resulting into smooth flow of traffic and reduction in accident n umbers. Also, LED car lights can alert drivers when other vehicles are too close.
- ***Mobile Connectivity:*** Mobiles, laptops, tablets, and other smart phones can easily con nect with each other. The short-range network of Li-Fi can yield exceptionally high da ta rates and higher security.
- ***Replacement for other technologies:*** Li-Fi doesn’t work using radio waves. So, it can be easily used in the places where Bluetooth, infrared, Wi-Fi, etc. are prohibited.

4.3 Advantages of Li-Fi

Li-Fi, which uses visible light to transmit signals wirelessly, is an emerging technology poised to compete with Wi-Fi. Advantages of Li-Fi technology includes:

- ***Efficiency:*** Energy consumption can be minimized with the use of LED illumination which are already available in the home, offices and Mall etc. for lighting purpose. He nce the transmission of data requiring negligible additional power, which makes it ver y efficient in terms of costs as well as energy.
- ***High speed:*** Combination of low interference, high bandwidths and high-intensity out put, help Li-Fi provide high data rates i.e. 1 Gbps or even beyond.
- ***Availability:*** Availability is not an issue as light sources are present everywhere. Whe rever there is a light source, there can be Internet. Light bulbs are present everywhere – in homes, offices, shops, malls and even planes, which can be used as a medium for the data transmission.
- ***Cheaper:*** Li-Fi not only requires fewer components for its working, but also uses only a negligible additional power for the data transmission.
- ***Security:*** One main advantage of Li-Fi is security. Since light cannot pass through op aque structures, Li-Fi internet is available only to the users within a confined area and cannot be intercepted and misused, outside the area under operation.

4.4 Limitations of Li-Fi

Some of the major limitations of Li-Fi are:

- Internet cannot be accessed without a light source. This could limit the locations and s ituations in which Li-Fi could be used.
- It requires a near or perfect line-of-sight to transmit data
- Opaque obstacles on pathways can affect data transmission
- Natural light, sunlight, and normal electric light can affect the data transmission speed
- Light waves don’t penetrate through walls and so Li-Fi has a much shorter range than Wi-Fi.

CHAPTER 5

Conclusion & Future Scope

5.1 Conclusion

Although there's still a long way to go to make this technology a commercial success, it promises a great potential in the field of wireless internet. A significant number of researchers and companies are currently working on this concept, which promises to solve the problem of lack of radio spectrum, space and low internet connection speed. By deployment of this technology, we can migrate to greener, cleaner, safer communication networks. The very concept of Li-Fi promises to solve issues such as, shortage of radio-frequency bandwidth and eliminates the disadvantages of Radio communication technologies. Li-Fi is the upcoming and growing technology acting as catalyst for various other developing and new inventions. Therefore, there is certainty of development of future applications of the Li-Fi which can be extended to different platforms and different areas of human life.

5.2 Future Scope

As light is everywhere and free to use, there is a great scope for the use and evolution of Li-Fi technology. If this technology becomes mature, each Li-Fi bulb can be used to transmit wireless data. As the Li-Fi technology becomes popular, it will lead to a cleaner, greener, safer communications and have a bright future and environment. The concept of Li-Fi is deriving many people as it is free (require no license) and faster means of data transfer. If it evolves faster, people will use this technology more and more. Currently, LBS (location Based Service) or Broadcast solution are commercially available. The next step could be a Li-Fi WLAN for B2B market with high added value on specific business cases and could grow towards mass market. In the long term, the Li-Fi could become an alternative solution to radio for wireless high data rate room connectivity and new adapted service, such as augmented or virtual reality.

Appendix

Code for Transmitter

```
#include <Keypad.h>

#define LED_PIN 12
#define PERIOD 10

String inp = "";
int string_length;

const byte ROWS = 4;
const byte COLS = 4;
char keys[ROWS][COLS] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8','9','C'},
  {'*','0','#','D'}
};

byte rowPins[ROWS] = {9, 8, 7, 6};
byte colPins[COLS] = {5, 4, 3, 2};

Keypad keypad(makeKeymap(keys), rowPins, colPins, ROWS, COLS);

void setup() {
  pinMode(LED_PIN, OUTPUT);
  Serial.begin(9600);
  Serial.setTimeout(10);
  Serial.println("Hello From Transmitter 2!");
  digitalWrite(LED_PIN, LOW);
}

void loop()
{
  inp = "";
  char key = keypad.getKey();
  if (key != NO_KEY) {
    inp += key;
    sendMessage(inp);
    Serial.println(inp);
    Serial.print("Done");
    Serial.println();
    digitalWrite(LED_PIN, LOW);
  }
}
```

```
void sendMessage(String string) {
  int string_length = string.length();
  Serial.println("Initiated");
  digitalWrite(LED_PIN, HIGH);
  delay(PERIOD);
  for (int i = 0; i < string_length; i ++) {
    send_byte(string[i]);
    if ((i % 3 == 0 and i != 0) or i == 2)   wait_time();
  }
  digitalWrite(LED_PIN, LOW);
}

void wait_time() {
  digitalWrite(LED_PIN, LOW);
  delay(PERIOD * 10);
  digitalWrite(LED_PIN, HIGH);
  delay(PERIOD);
  return;
}

void send_byte(char my_byte) {
  String bits = "";
  for (int i = 7; i >= 0; --i) {
    int state = (my_byte & (1 << i))? 1 : 0;
    digitalWrite(LED_PIN, state);
    Serial.print(state);
    delay(PERIOD);
  }
  Serial.print(" -> ");
  Serial.print(my_byte);
  Serial.println();
  return;
  digitalWrite(LED_PIN, HIGH);
  delay(PERIOD);
}
```

Code for Receiver

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define LED_PIN 13
#define PHOTODIODE_PIN 12
#define THRESHOLD 0
#define PERIOD 10
#define MAX_BYTES 64

bool previous_state;
bool current_state;
int cursorX = 0;
int cursorY = 0;

LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
  Serial.begin(9600);
  pinMode(LED_PIN, OUTPUT);
  lcd.begin();
  lcd.backlight();
  digitalWrite(LED_PIN, LOW);
  lcd.setCursor(0, 0);
  lcd.print("....Li-Fi Rx....");
  lcd.setCursor(0, 1);
  lcd.print("KEY = ");
}

void loop() {
  current_state = get_PHOTODIODE();
  if (current_state && !previous_state) {
    digitalWrite(LED_PIN, HIGH);
    delay(PERIOD * 1.5);
    char receivedBytes[MAX_BYTES];
    int byteCount = 0;
    String receivedString = "";

    while (1) {
      char ch = get_byte();
      if (ch == '\n') {
        //updateLCD(receivedString);
        digitalWrite(LED_PIN, LOW);
        break;
      } else if (ch == NULL || byteCount >= MAX_BYTES) {
        break;
      } else {
```

```
        receivedBytes[byteCount++] = ch;
        receivedString += ch;
        lcd.setCursor(0, 0);
        lcd.print("....Li-Fi Rx....");
        lcd.setCursor(0, 1);
        lcd.print("KEY = ");
        lcd.setCursor(6, 1);
        lcd.print(ch);

      }
    }
  }
  previous_state = current_state;
}

bool get_PHOTODIODE() {
  int voltage = digitalRead(PHOTODIODE_PIN);
  return voltage > THRESHOLD ? false : true;
}

char get_byte() {
  int res = 0;
  int pov = 128;
  for (int i = 0; i < 8; i++) {
    bool volt = digitalRead(PHOTODIODE_PIN) > THRESHOLD ? false : true;
    res += volt * pov;
    pov /= 2;
    delay(PERIOD);
  }
  char character = res;
  Serial.print(character);

  return res;
}
```

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