CHAPTER 1

INTRODUCTION

Problem Statement:

Over the years, the usage of Wireless Fidelity has become common in every household. Almost every electronic device at home operates on Wi-Fi. But this overdependence on Wi-Fi for data transmission made the need for an alternate and more reliable means of communication a necessity. Hence, Light-Fidelity.

1.1 Introduction

The main objective of this project is to use Li-Fi which is an advanced communication technology which can be 100 times faster than Wi-Fi communication. While Wi-Fi can cover an entire place, its bandwidth is restricted to 50-100 megabits per second (Mbps) [1]. Using this technology, the data can be transferred using visible light sources. Imagine, if you can access to high-speed internet by just using your light source.

Li-Fi uses visible light as a communication medium for the transmission of data. A LED can act as a light source and the photodiode acts as a transceiver that receives light signals and transmits them back. By controlling the light pulse at the transmitter side, we can send unique data patterns. This phenomenon occurs at extremely high speed and can't be seen through the human eye. Then at the receiver side, the photodiode or Light-dependent resistor (LDR) converts the data into useful information.

In the transmitter part of Li-Fi communication, 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 control unit, which is Arduino in our case. 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.

1.2 Block Diagram:

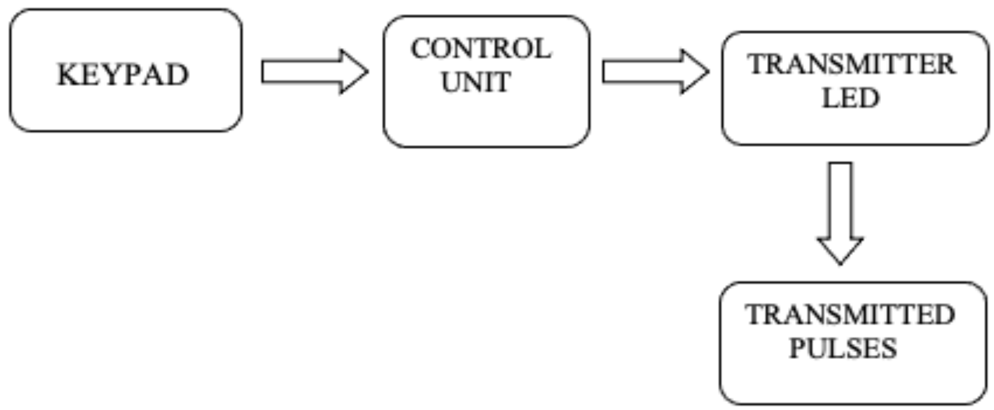

Figure 1.1: Block Diagram of Transmitter

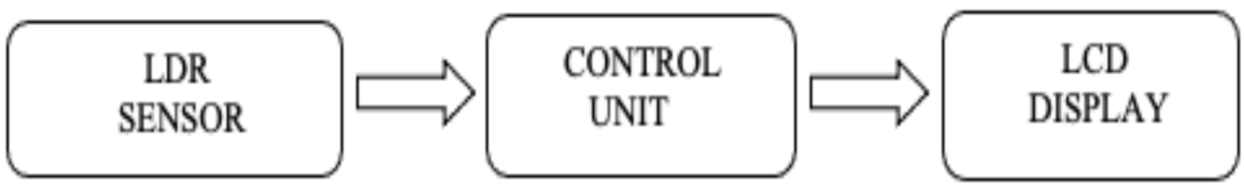

Figure 1.2: Block Diagram of Receiver

1.3Hardware Requirements:

- Arduino UNO
- LDR Sensor
- 4*4 Keypad
- 16*2 Alphanumeric LCD
- I2C Interface module for LCD
- Breadboard
- Connecting Jumpers
- 5 mm LED

1.4 Cost of the project:

S. No	Name	Model	Quantity	Cost in Rs
1	Arduino	UNO	1	325
2	Arduino	MEGA	1	670
3	4*4 Keypad		1	85
4	16*2 Alphanumeric LCD		1	125
5	LED	5mm	1	1
6	Potentiometer		1	200
7	Resistors	1k, 10k	1	2
8	Breadboard	Full Size (Bare)	1	65
9	IR (Tx, Rx)		1	12
10	LDR		1	20
11	Connecting wires		1bunch	50
12	Total cost of project			1555

Table 1.1 Cost of the project

1.5 Advantages:

1 High data speed

2 High security

3 Low power and high efficiency

4 Less harmful to humans

5 Low implementation and maintenance

6 Less cost

1.6 Disadvantages:

- Restricted Range and Connectivity
- Inaccessibility of Compatible Technologies
- Light Interference and Light Pollution
- Conceivable Cost Implications

1.7 Applications:

- Cryptocurrency
- Underwater applications
- Navy (Submarine communication)
- Military
- Airports 4.0
- Augmented reality
- Industry 4.0(IOT, AI)
- Disaster management
- Retail
- Seamless network connectivity
- Pharmaceutical industry
- Live streaming

CHAPTER-II
LITERATURE SURVEY

2.1 About:

This paper describes about Li-Fi which is a new technology for short range wireless technology to provide connectivity within localized network environment. This technology provides a THz visible light communication (VLC) which sends the data by flashing the light at speeds undetectable to human eyes. The LED lights used in Li-Fi are cheap, durable, and secure and provide good performance. VLC is free of any health concerns, as it uses eco-friendly green technology rather than microwaves, which can cause harm to human body. If PLC is combined with VLC, there would be more benefit and the use of Li-Fi for wireless connection to devices by a simple plug-and-play technique.

The VLC systems use LED to send data by flashing light at speeds undetected to human eyes. LEDs are more advantageous than the existing fluorescent tubes. The visible light occupies unregulated and unlicensed THz spectrum since it does not cause or suffer from any electromagnetic interference, whereas interference is common using Wi-Fi or any other RF systems. VLC is free from any health concerns, as it uses eco-friendly green technology rather than microwaves, which can cause harm to human body.

2.2 History:

From the University of Edinburgh in the UK, Professor Herald Haas the founder of Light Fidelity, “Data through Illumination” i.e Li-Fi - taking the fiber out of fiber optics by sending data through an LED light bulb that differs in intensity faster than the human eye can follow [2, 3]. By August 2013, data rates over 1.6 Gbps were exposed over a single color LED. September 2013, a press release said that Li-Fi, or Visible Light Communication systems generally, do not require line of sight conditions [3]. Li-Fi is now a part of Visible Light Communication (VLC) PAN IEEE 802.15.7 standard. The technology was demonstrated in Las Vegas at the 2012 Consumer Electronics show using a pair of Casio smart phones to exchange data using light of variable intensity given off from their screens, evident at a distance of up to ten meters.

A survey on Transmission of data through illumination - Li-Fi paper talks about Wi-Fi is the most used technology by everyone, but there is an emerging technology Li-Fi, which refers to apparent light communication systems that uses light from light-emitting diodes (LEDs) as a standard to deliver mobile, networked, high-speed communication in a similar manner as Wi-Fi. Visible light communications (VLC) indicates by switching bulbs on and off within nanoseconds, which is too rapid for the human eye to notice. Although Li-Fi bulbs would have to be kept on to transmit data, the bulbs could be dimmed to the point that they were not visible to humans and yet still functional. Direct line of sight is not necessary for Li-Fi to send signal and light reflected off of the walls can accomplish 70 Mbps. There are approximately 19 billion bulbs worldwide, which just need to be replaced with LED so that it would allow data transmission.

The data transmission in Li-Fi is done by turning the LED blubs on-off so fast that it cannot be detected by human eyes. Switching on and LED is a logical '1', switching it off is a logical '0'. A light sensitive device receives the signal and converts it back into original data. Li-Fi is fast and cheap as compared to Wi-Fi.

Speed and security is a major concern while transmitting data. Data transmitted through Wi-Fi are susceptible to hackers as it penetrates through walls easily. Li-Fi on the other hand do not penetrate walls and so provides more security. The main component of Li-Fi communication is the white LED, which acts as a communication source and a silicon photodiode which shows good response to visible light. A data rate of greater than 100Mbps is possible by the high speed LEDs.

2.3 Need for LI-FI :

- VLC can be used safely in aircrafts.
- Integrated into medical devices and in hospitals as this technology does not deal with radio waves, so it can easily be used in such places where Bluetooth, infrared, Wi-Fi and internet are banned.
- As light does not penetrate walls it provides better security.
- This technology will solve the issue of shortage of radio frequency bandwidth.
- Every street lamp would be a free access points for this technology.
- Wi-Fi does not work under water, which is possible using Li-Fi.

CHAPTER-III

METHODOLOGY

3.1 Introduction with circuit diagram:

LEDs are used as the source of light. The basic principle behind the working of this technology is if the LED is ON, digital HIGH will be transmitted and if LED is OFF, digital LOW will be transmitted. The LED flickers due to the large and subtle variation in the current, which is at the rate of 10Gbps so that the data is transmitted at a very high speed. The flickering rate of LEDs is varied so that the information encoded can be obtained in different sets of 0's and 1's.

The input data is given to the LED driver in the form of 1s and 0s which works on the principle of on and off keying. This makes the high illumination LED which is connected to the LED driver to flicker at a high rate and hence transmitting the optical pulses[4].

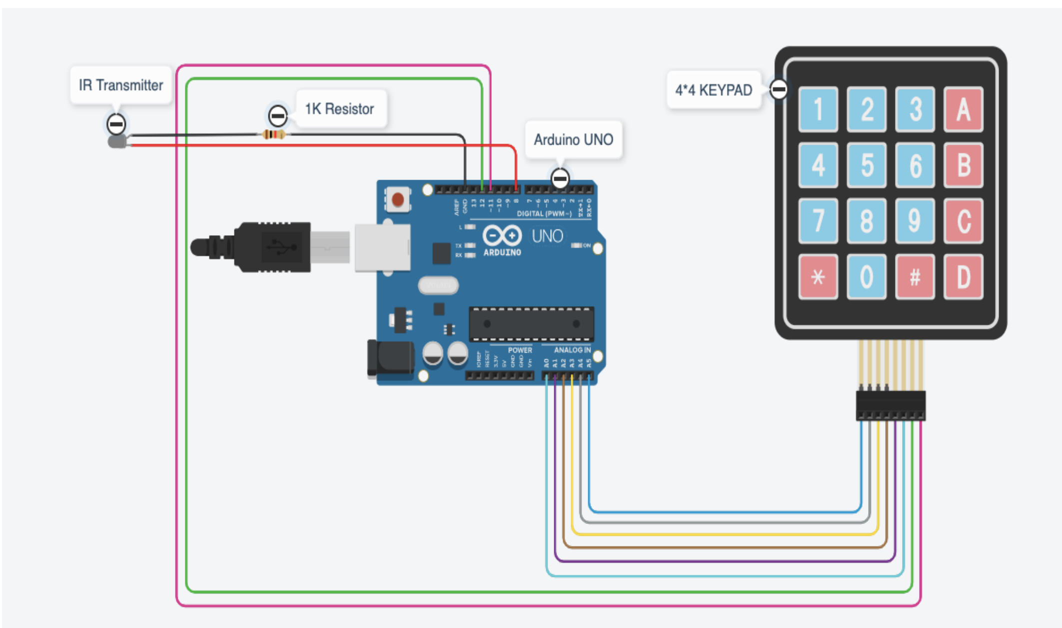

Fig 3.1.1: Circuit diagram of Transmitter

As shown in the figure, in the transmitter part of Li-Fi communication, 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 control unit which is nothing but Arduino in our case. 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.

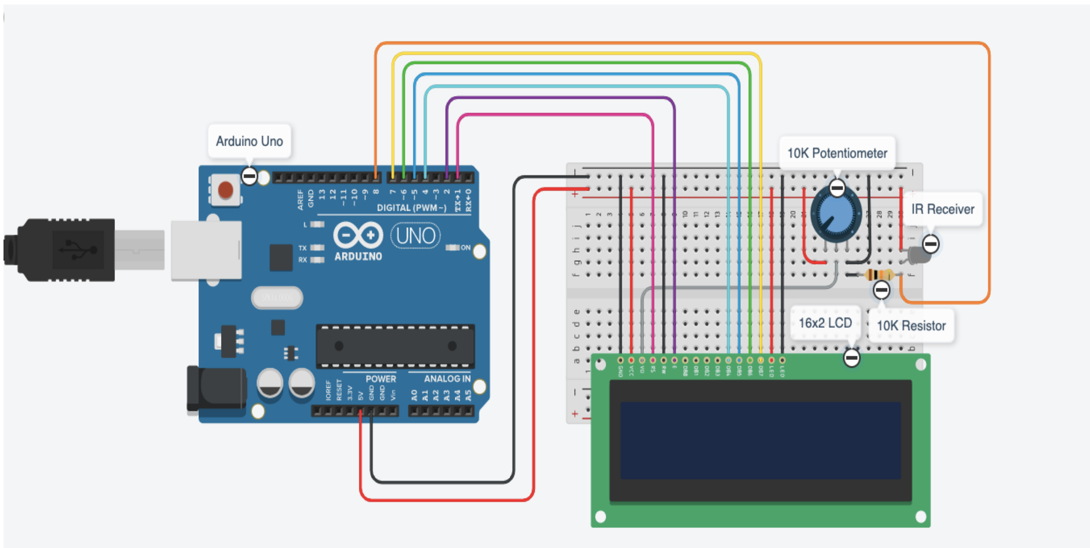

Fig 3.1.2: Circuit diagram of Receiver

In the receiver section, the LDR sensor receives the visible light pulses from the transmitter side and converts it into interpretable electrical pulses, which is fed to the Arduino (Control unit). Arduino receives this pulse and converts it into actual data and displays it on a 16x2 LCD display.

3.2 Hardware description:

3.2.1 Arduino UNO and MEGA

- Arduino Uno is a microcontroller board developed by Arduino.cc which is an open-source electronics platform mainly based on AVR microcontroller Atmega328.

- First Arduino project was started in Interaction Design Institute Ivrea in 2003 by David Cuartielles and Massimo Banzi with the intention of providing a cheap and flexible way to students and professional for controlling a number of devices in the real world.
- The current version of Arduino Uno comes with USB interface, 6 analog input pins, 14 I/O digital ports that are used to connect with external electronic circuits. Out of 14 I/O ports, 6 pins can be used for PWM output.
- It allows the designers to control and sense the external electronic devices in the real world.

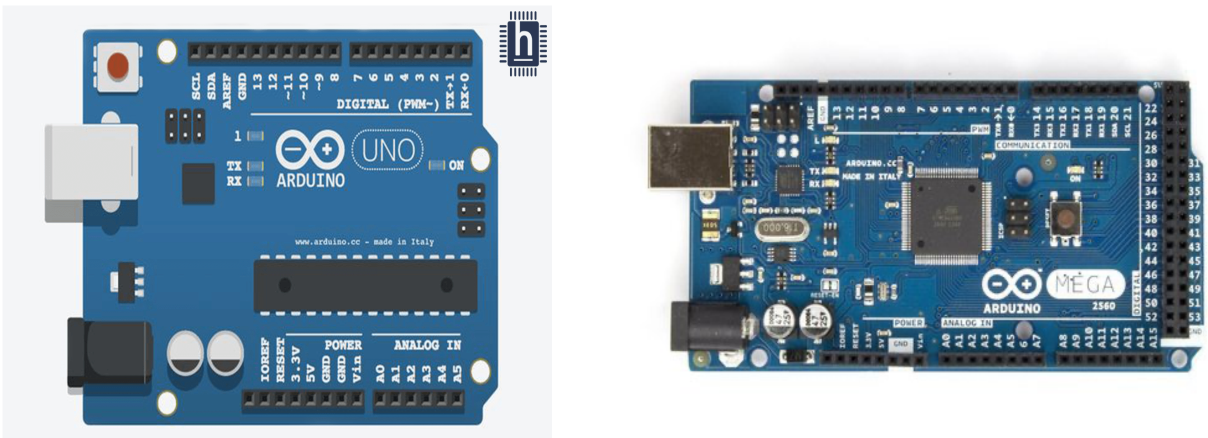

Fig 3.2.1: Arduino UNO and MEGA [Ref. Appendix A].

3.2.2 LDR Sensor:

A Light Dependent Resistor (LDR) is also called a photoresistor or a cadmium sulfide (CdS) cell. It is also called a photoconductor. It is basically a photocell that works on the principle of photoconductivity. The passive component is basically a resistor whose resistance value decreases when the intensity of light decreases. This optoelectronic device is mostly used in light varying sensor circuit, and light and dark activated switching circuits. Some of its applications include camera light meters, street lights, clock radios, light beam alarms, reflective smoke alarms, and outdoor clocks.

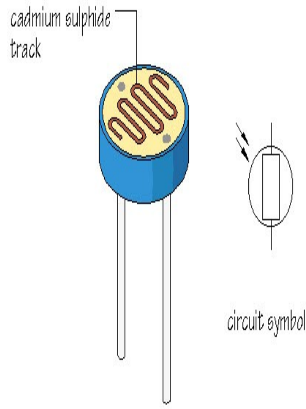

Fig 3.2.2 LDR Sensor [Ref. Appendix B].

3.2.3 16*2 Alphanumeric LCD:

An LCD is an electronic display module that uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates o a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×8 pixel matrix.

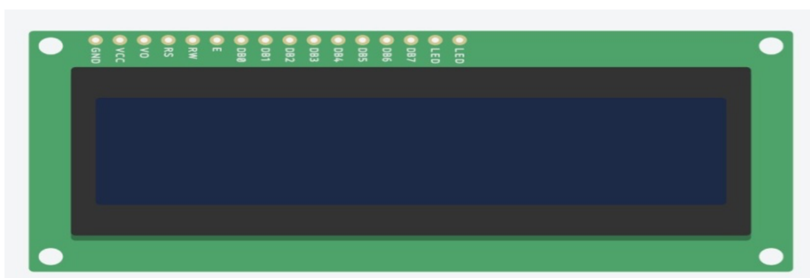

Fig 3.2.3 LCD Display. [Ref. Appendix C].

3.2.4 4*4 Keypad:

A 4X4 Keypad will have eight terminals. In them four are rows of matrix and four are columns of the matrix. These 8 pins are driven out from 16 buttons present in the module. Those 16 alphanumeric digits on the module surface are the 16 buttons arranged in matrix formation.

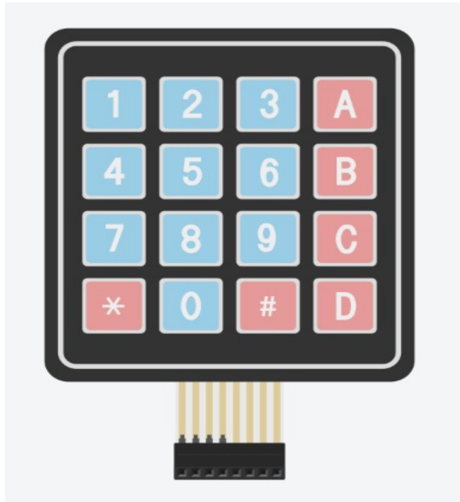

Fig 3.2.4 4*4 Keypad [Ref. Appendix D].

3.2.5 LED:

Light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it. Light is produced when the particles that carry the current (known as electrons and holes) combine together within the semiconductor material. 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).

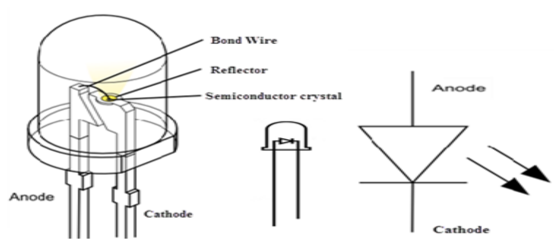

Fig 3.2.5 LED [Ref. Appendix E].

3.2.6 IR Transmitter and Receiver:

We use this high power 5 mm IR LED Transmitter and Receiver pair to build wireless remotes for appliances, distance sensors, and object sensors, colour sensors, line sensors, distance sensors, etc. It can be directly connected to a microcontroller, Arduino or Raspberry Pi with only a few current limiting resistors and require no complex circuit for getting it working. Both the transmitter and emitter are built to work on the 940 nm wavelength.

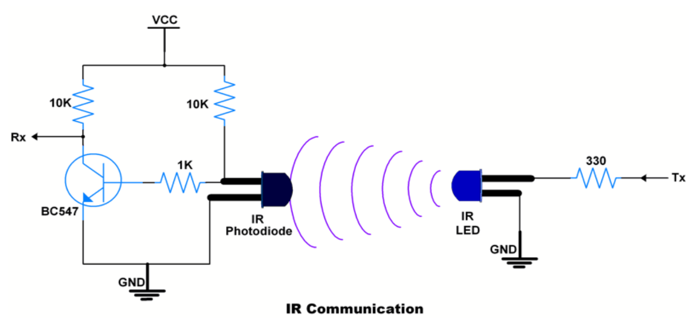

Fig 3.2.6 IR Transmitter and Receiver [Ref. Appendix F].

3.2.7 Potentiometer:

The instrument designs for measuring the unknown voltage by comparing it with the known voltage, such type of instrument is known as the potentiometer. In other words, the potentiometer is the three terminal device used for measuring the potential differences by manually varying the resistances. The known voltage is drawn by the cell or any other supply sources.

The potentiometer uses the comparative method which is more accurate than the deflection method. So, it is mostly used in the places where higher accuracy is required or where no current flows from the source under test. The potentiometer is used in the electronic circuit, especially for controlling the volume.

Fig 3.2.7 Potentiometer [Ref. Appendix G].

3.2.8 Resistor:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, **resistors** are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

Fig 3.2.8 Resistors (1k, 10k). [Ref. Appendix H].

3.2.9 Breadboard:

A **breadboard** is used to build and test circuits quickly before finalizing any circuit design. The **breadboard** has many holes into which circuit components like ICs and resistors can be inserted. ... The **bread board** has strips of metal which run underneath the board and connect the holes on the top of the board.

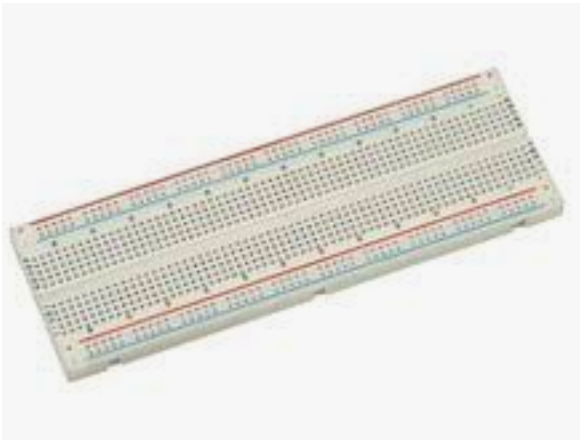

Fig 3.2.9 Breadboard. [Ref. Appendix I].

CHAPTER 4
SOFTWARE DESCRIPTION

4.1 Introduction:

The Software which we use in this project is Arduino software. The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog. Beginning with version 1.0, files are saved with an .ino file extension. Previous versions use the .pde extension. We may still open .pde named files in version 1.0 and later, the software will automatically rename the extension to .ino.

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager.

Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino boot loader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The boot loader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The boot loader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

4.2 Transmitter Code:

```
#include<Keypad.h>
const byte ROW = 4;
const byte COL = 4;
char keyscode[ROW][COL] = {
  {'1', '2', '3', 'A'},
  {'4', '5', '6', 'B'},
  {'7', '8', '9', 'C'},
  {'*', '0', '#', 'D'}
};
byte rowPin[ROW] = {A5, A4, A3, A2};
byte colPin[COL] = {A1, A0, 12, 11};
Keypad customKeypad = Keypad( makeKeymap(keyscode), rowPin, colPin, ROW, COL);
char keycount = 0;
char code[5];
void setup()
{
  Serial.begin(9600);
  pinMode(8,OUTPUT);
  digitalWrite(8,LOW);
}
void loop()
{
  char customKey = customKeypad.getKey();
  if (customKey)
{
    Serial.println(customKey);
   if (customKey == '1')
   {
    digitalWrite(8,HIGH);
```

```
  delay(10);
  digitalWrite(8,LOW);
}
else if (customKey == '2')
{
  digitalWrite(8,HIGH);
  delay(20);
  digitalWrite(8,LOW);
}
else if (customKey == '3')
{
  digitalWrite(8,HIGH);
  delay(30);
  digitalWrite(8,LOW);
}
else if (customKey == '4')
{
  digitalWrite(8,HIGH);
  delay(40);
  digitalWrite(8,LOW);
}
else if (customKey == '5')
{
  digitalWrite(8,HIGH);
  delay(50);
  digitalWrite(8,LOW);
}
else if (customKey == '6')
{
  digitalWrite(8,HIGH);
  delay(60);
  digitalWrite(8,LOW);
}
else if (customKey == '7')
{
  digitalWrite(8,HIGH);
  delay(70);
  digitalWrite(8,LOW);
}
else if (customKey == '8')
{
  digitalWrite(8,HIGH);
```

```
  delay(80);
  digitalWrite(8,LOW);
 }
 else if (customKey == '9')
 {
  digitalWrite(8,HIGH);
  delay(90);
  digitalWrite(8,LOW);
 }
 else if (customKey == '*')
 {
  digitalWrite(8,HIGH);
  delay(100);
  digitalWrite(8,LOW);
 }
 else if (customKey == '0')
 {
  digitalWrite(8,HIGH);
  delay(110);
  digitalWrite(8,LOW);
 }
 else if (customKey == '#')
 {
  digitalWrite(8,HIGH);
  delay(120);
  digitalWrite(8,LOW);
 }
 else if (customKey == 'A')
 {
  digitalWrite(8,HIGH);
  delay(130);
  digitalWrite(8,LOW);
 }
 else if (customKey == 'B')
 {
  digitalWrite(8,HIGH);
  delay(140);
  digitalWrite(8,LOW);
}
 else if (customKey == 'C')
 {
  digitalWrite(8,HIGH);
```

```
    delay(150);
    digitalWrite(8,LOW);
  }
else if (customKey == 'D')
  {
    digitalWrite(8,HIGH);
    delay(160);
    digitalWrite(8,LOW);
 }
 else;
  }
}
```

4.3 Receiver Code:

```
#include <Wire.h>
#include <LiquidCrystal.h>
LiquidCrystal lcd(1, 2, 4, 5, 6, 7);
#include <SoftwareSerial.h>
#include <Keypad.h>
void setup()
{
 lcd.begin(16,2);
}
void loop()
{
 lcd.print("welcome"); // Prints “welcome” on the LCD
 delay(2000); // 2 seconds delay
 lcd.setCursor(2,1); // Sets the location at which subsequent text written to the LCD will be displayed
 lcd.print("to LIFI"); // Prints “to LIFI” on the LCD
 delay(6000);
 lcd.clear(); // Clears the display
  unsigned long duration = pulseIn(8, HIGH);
  Serial.println(duration);
  if (duration > 10000 && duration < 17000)
  {
    lcd.setCursor(0, 0);
    lcd.print("Received: 1          ");
  }
```

```
else if (duration > 20000 && duration < 27000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 2          ");
}
else if (duration > 30000 && duration < 37000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 3          ");
}
else if (duration > 40000 && duration < 47000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 4          ");
}
else if (duration > 50000 && duration < 57000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 5          ");
}
else if (duration > 60000 && duration < 67000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 6          ");
}
else if (duration > 70000 && duration < 77000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 7          ");
}
else if (duration > 80000 && duration < 87000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 8          ");
}
else if (duration > 90000 && duration < 97000)
{
  lcd.setCursor(0, 0);
  lcd.print("Received: 9          ");
}
else if (duration > 100000 && duration < 107000)
{
```

```
    lcd.setCursor(0, 0);
    lcd.print("Received: *         ");
  }
  else if (duration > 110000 && duration < 117000)
  {
    lcd.setCursor(0, 0);
    lcd.print("Received: 0         ");
  }
  else if (duration > 120000 && duration < 127000)
  {
    lcd.setCursor(0, 0);
    lcd.print("Received: #         ");
  }
  else if (duration > 130000 && duration < 137000)
  {
    lcd.setCursor(0, 0);
    lcd.print("Received: A         ");
  }
  else if (duration > 140000 && duration < 147000)
  {
    lcd.setCursor(0, 0);
    lcd.print("Received: B         ");
  }
  else if (duration > 150000 && duration < 157000)
  {
    lcd.setCursor(0, 0);
    lcd.print("Received: C         ");
  }
  else if (duration > 160000 && duration < 167000)
  {
    lcd.setCursor(0, 0);
    lcd.print("Received: D         ");
  }
}
```

CHAPTER 5

RESULTS

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

The possibilities are numerous and can be explored further. Researchers are developing micron sized LED which are able to flicker on & off around 1000 times quicker than larger LED. They offer faster data transfers and take up less space so as to save space or add more LED's to further boost the channel of communication. Also 1000 micron sized LED can fit into area required by 1sq. mm large single LED. A 1 sq.mm sized array of micron sized LED's could therefore communicate 1000×1000 (i.e. a million) times as much information as a single 1mm LED [2]. If this technology can be implemented practically then all the bulbs can be used as Wi-Fi hotspots to transmit data without the use of wire, as well as it will allow for safer, cleaner and better future.

The new Li-Fi technology is being studied and trying to put in practice as it would offer a great deal of efficient substitute to wire as well as radio wave technology. With the increase in the population and the advent of the many devices that access wireless internet, the Wi-Fi also can be termed as airwaves are becoming progressively clogged thus resulting into difficulty to get a better and reliable speed signal. This would solve the problems like the shortage of radio-frequency bandwidth and allow internet to be used in places and situations where it cannot be used currently like the hospitals or aircrafts.

APPENDIX

Appendix A

About Arduino:

Arduino is a made up name that was easy to copyright, it doesn't stand for anything and doesn't have any meaning. It was conceived as a way of introducing microcontrollers to beginners by a group in Italy and the Arduino hardware and software is released under a open source license so that anyone can copy it. The name is copyrighted so that you need a license to use it to sell your product as Arduino but this is being ignored by lots of Chinese companies.
It has two elements, hardware and software that form a system to rapidly develop microcontroller projects. It is based on the Atmel AVR microcontroller but you do not need to know this and it is hidden beneath the surface, which is one of the disadvantages of Arduino.

Alternatives:

Arduino is an electronics prototyping system designed to simplify microcontroller projects. The idea is to create these projects without having to know much about microcontrollers or programming, microcontrollers for dummies is one way of describing Arduino.

Arduino is excellent for carrying out a specific microcontroller project, especially if the same or a similar project has already been done. However, it is a bit like painting by numbers as you actually learn very little. If you want to understand microcontrollers and how to program them, you need a microcontroller course that will cover all the basics. This includes things like microcontroller layout, logic, numbering systems and program planning.

Once you have covered the basics, assembly language teaches you about the AVR (or PIC) microcontroller and its peripherals like serial ports, buses and ADC. The next step is to move on to C programming as this is the best language for real development. This involves more work than grabbing an Arduino but you will be in a better position to design and develop your own projects once you have a better understanding.

Kanda produce microcontroller learning kits for both PIC and AVR microcontrollers, going back to 1995 so we know what we are doing. These kits include books, sample code, guides and hardware including a full AVR board or PIC board, debugger and programmer to load and test your code.

Hardware of Arduino:

It consists of a simple base board that has the microcontroller and its support circuitry with connectors to connect to plug in modules and a USB interface to download code from the PC. The commonest one is called Arduino Uno, which uses Atmel ATmega328P microcontroller, but there are now several others.

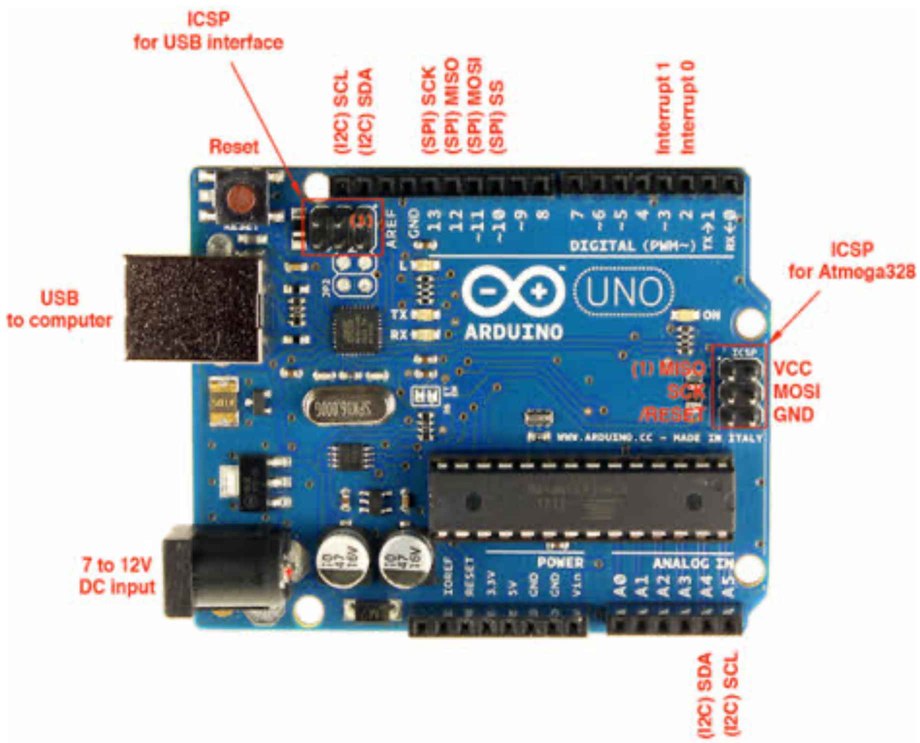

Fig. A1: Arduino Uno (Hardware)

This baseboard does not do much on its own and you need to plug in expansion modules, called Shields to do anything meaningful.

There are hundreds of different shields available that provide varied projects like robot controllers, relay outputs, plant monitoring projects and many more. If someone has already done something similar, then you can just buy the shield and your project is virtually done. As they are open source, PCB files are usually available for free Eagle software. There are prototype shields that allow you to make your own circuit. Theoretically, you can stack shields on top of each other but in practice you get problems with conflicts as they use the same pins and really need to be designed together.

Software of Arduino:

The software is an open source development environment, written in Java that can run under Linux, MAC or Windows. It runs a simple programming language called **Wiring**, which makes it fairly easy to write scripts to make the microcontroller carry out tasks. These scripts are called **Sketches** by Arduino. Most shields come with sketches already written that can be loaded in to the software, compiled and downloaded to the base board.

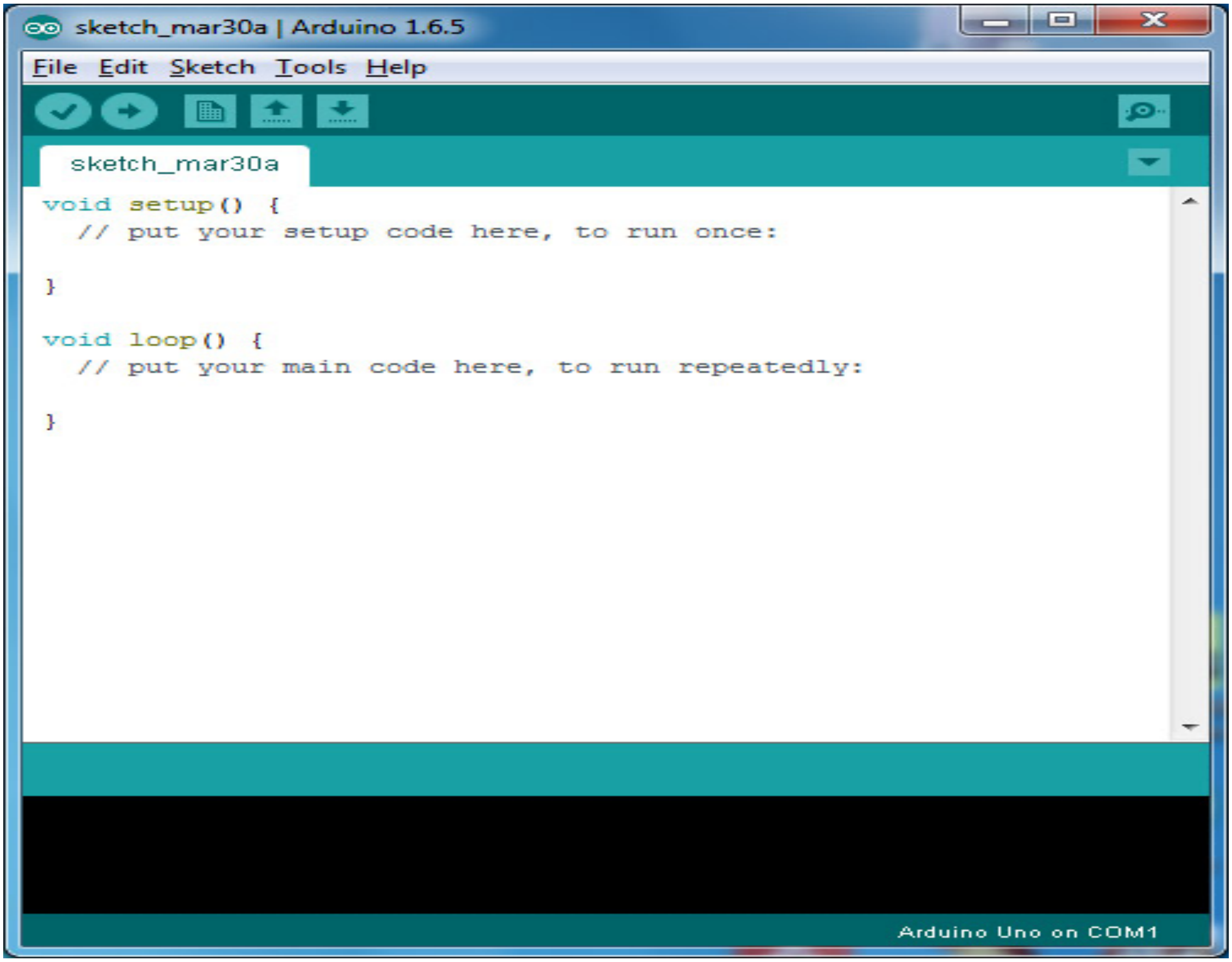

Fig. A2: Arduino Software

These scripts are a very simplified form of C, with a setup function for initialisation and a main function that runs code repeatedly.

Features:

- The operating voltage is 5V
- The recommended input voltage will range from 7v to 12V
- The input voltage ranges from 6v to 20V
- Digital input/output pins are 14
- Analog i/p pins are 6
- DC Current for each input/output pin is 40 mA
- DC Current for 3.3V Pin is 50 mA
- Flash Memory is 32 KB
- SRAM is 2 KB

- EEPROM is 1 KB
- CLK Speed is 16 MHz

Pin Diagram:

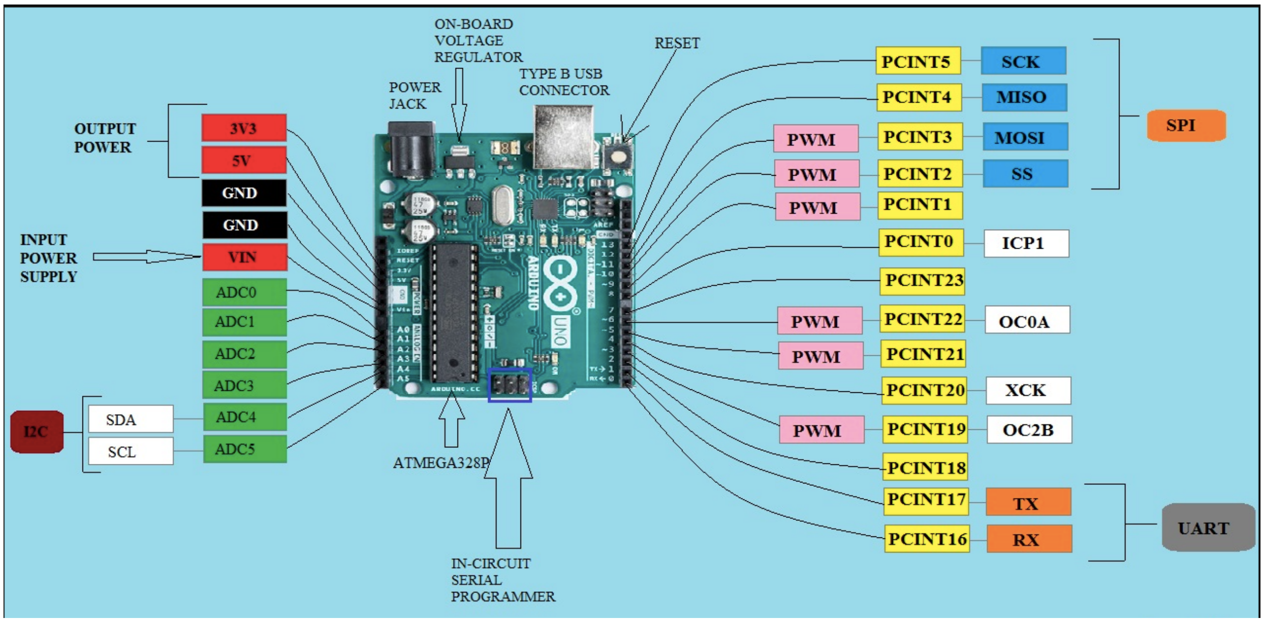

Fig. A3: Pin diagram of Arduino

Pin description:

Pin Category	Pin Name	Details
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external power source. 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: ground pins.
Reset	Reset	Resets the microcontroller.

Analog Pins	A0 – A5	Used to provide analog input in the range of 0-5V
Input/Output Pins	Digital Pins 0 - 13	Can be used as input or output pins.
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.
AREF	AREF	To provide reference voltage for input voltage.

Comparison Table of Arduino Mega vs Uno:

Mega	Uno
Mega is used by engineers who are interested in hardcore electronics and it is not highly software compatible.	Uno is the popular Arduino due to its smaller size and compatibility with software and hardware in the system.
The size is big and it does not fit easily with smaller development boards so designers	The smaller size of the controller helps it easily fit with any development board and

cannot carry them easily all around. It cannot be used in space-restricted applications.	designers can carry it easily around the boarding system.
Since the user interface is used more, there are a large number of interfaces that makes the architecture heavy.	There is no user interface and hence fewer interfaces are used. The architecture is light when compared with MVP.
Desktop prototyping cannot be done obviously due to its size and shields cannot be used for the same.	Desktop prototyping can be easily done in the system with the use of shields as the size is small and memory is also less.
Bootloader footprint is 4kB or 8kB depending on the model used in the system.	Bootloader footprint is only 0.5kB and it does not work well with heavy load projects.
The reset button is not strong and does not reset everything in the system. It is difficult to erase the memory of the controller all at once.	The reset button is stronger and brings the controller back to its starting position in Uno.
Permanent storage memory is 4kB EEPROM with working storage and memory storage being added to the system.	Permanent storage memory is 1kB EEPROM and there are other working storage and flash memory storage.

Advantages:

- Not much knowledge required to get started
- Fairly low cost, depending on shields you need
- Lots of sketches and shields available.

Disadvantages:

- No understanding of the AVR microcontroller
- Sketches and shields can be difficult to modify
- No debugger included for checking scripts
- You get no experience of C or professional development tools

Applications :

- It is used in Do-it-Yourself projects prototyping.
- In developing projects based on code-based control
- Development of Automation System
- Designing of basic circuit designs.

Appendix B

About LDR:

Light dependent resistors, LDRs or photoresistors are often used in electronic circuit designs where it is necessary to detect the presence or the level of light. A photoresistor or light dependent resistor is an electronic component that is sensitive to light.

When light falls upon it, then the resistance changes. Values of the resistance of the LDR may change over many orders of magnitude the value of the resistance falling as the level of light increases.

It is not uncommon for the values of resistance of an LDR or photoresistor to be several megohms in darkness and then to fall to a few hundred ohms in bright light. With such a wide variation in resistance, LDRs are easy to use and there are many LDR circuits available. The sensitivity of light dependent resistors or photoresistors also varies with the wavelength of the incident light.

LDR / Photoresistor symbol:

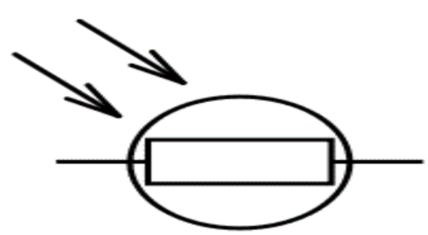

Fig. B1: LDR symbol

Photo resistor / LDR structure:

Structurally the photoresistor is a light sensitive resistor that has a horizontal body that is exposed to light. The active semiconductor region is normally deposited onto a semi-insulating substrate and the active region is normally lightly doped.

In many discrete photoresistor devices, an inter digital pattern is used to increase the area of the photoresistor that is exposed to light. The pattern is cut in the metallization on the surface of the active area and this lets the light through. The two metalized areas act as the two contacts for the resistor. This area has to be made relatively large because the resistance of the contact to the active area needs to be minimized.

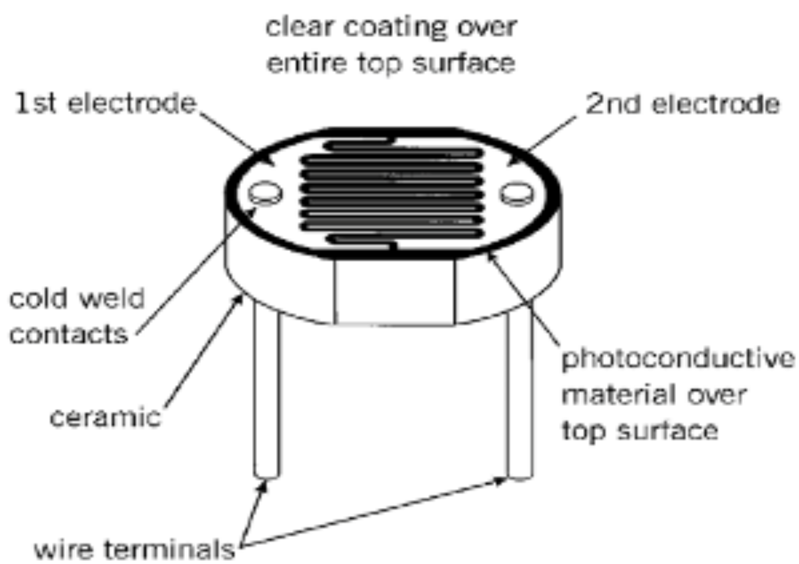

Fig. B2: LDR structure

LDR Construction:

The structure of a **light-dependent** resistor consists of a light-sensitive material which is deposited on an insulating substrate such as ceramic. The material is deposited in a zigzag pattern in order to obtain the desired resistance and power rating. This zigzag area separates the metal deposited areas into two regions.

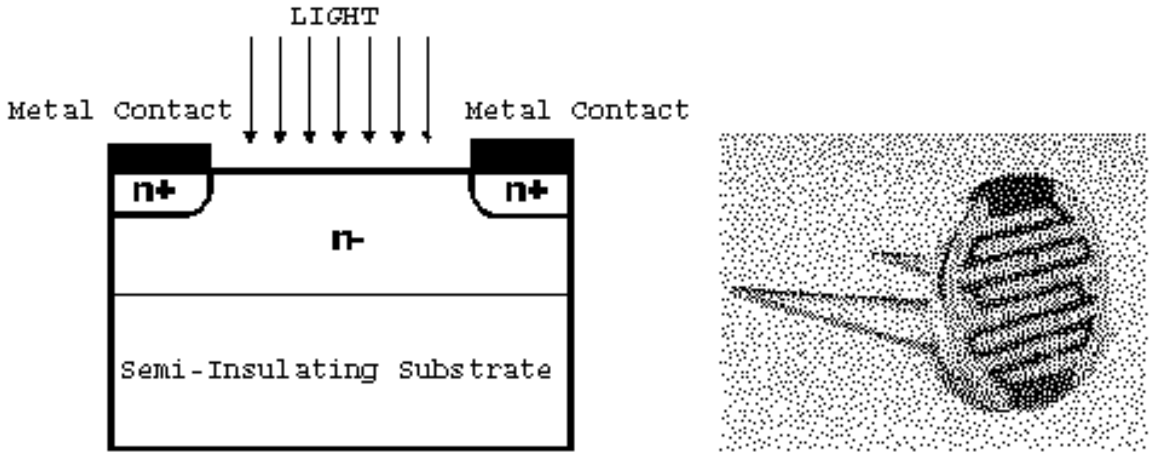

Fig. B3: LDR construction

Then the ohmic contacts are made on either sides of the area. The resistances of these contracts should be as less as possible to make sure that the resistance mainly changes due to the effect of light only. Materials normally used are cadmium sulphide, cadmium selenide, indium antimonide, and cadmium sulphide. The use of lead and cadmium is avoided as they are harmful to the environment.

LDR working:

It is relatively easy to understand the basics of how an LDR works without delving into complicated explanations. It is first necessary to understand that an electrical current consists of the movement of electrons within a material.

Good conductors have a large number of free electrons that can drift in a given direction under the action of a potential difference. Insulators with a high resistance have very few free electrons, and therefore it is hard to make them move and hence a current to flow.

A LDR or photoresistor is made any semiconductor material with a high resistance. It has a high resistance because there are very few electrons that are free and able to move - the vast majority of the electrons are locked into the crystal lattice and unable to move. Therefore in this state there is a high LDR resistance.

As light falls on the semiconductor, light photons are absorbed by the semiconductor lattice and some of their energy is transferred to the electrons. This gives some of them sufficient energy to break free from the crystal lattice so that they can then conduct electricity. This results in lowering the resistance of the semiconductor and hence the overall LDR resistance.

The process is progressive, and as more light shines on the LDR semiconductor, so more electrons are released to conduct electricity and the resistance falls further.

Types of photoresistor:

Light dependent resistors, LDRs or photoresistors fall into one of two types or categories:

- **Intrinsic photoresistors:** Intrinsic photoresistors use un-doped semiconductor materials including silicon or germanium. Photons fall on the LDR excite electrons moving them from the valence band to the conduction band. As a result, these electrons are free to conduct electricity. The more light that falls on the device, the more electrons are liberated and the greater the level of conductivity, and this results in a lower level of resistance.
- **Extrinsic photoresistors:** Extrinsic photoresistors are manufactured from semiconductor of materials doped with impurities. These impurities or dopants create a new energy band above the existing valence band. As a result, electrons need less energy to transfer to the conduction band because of the smaller energy gap.

Regardless of the type of light dependent resistor or photoresistor, both types exhibit an increase in conductivity or fall in resistance with increasing levels of incident light.

Photoresistor applications:

Photoresistors (LDRs) have low cost and simple structure and are often used as light sensors. Other applications of photoresistors include:

- Detect absences or presences of light like in a camera light meter.
- Used in street lighting design
- Alarm clocks
- Burglar alarm circuits
- Light intensity meters
- Used as part of a SCADA system to perform functions such as counting the number of packages on a moving conveyor belt.

Appendix C

About LCD:

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

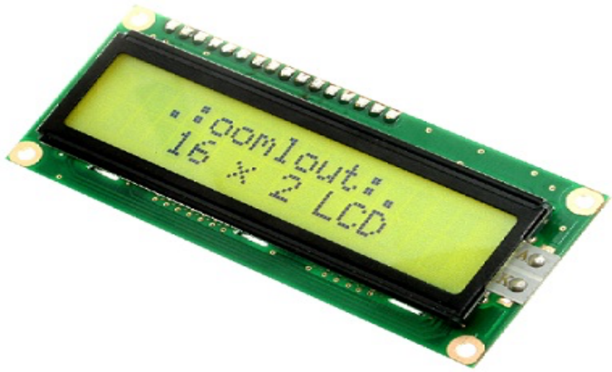

Fig. C1: LCD display

Pin Configuration :

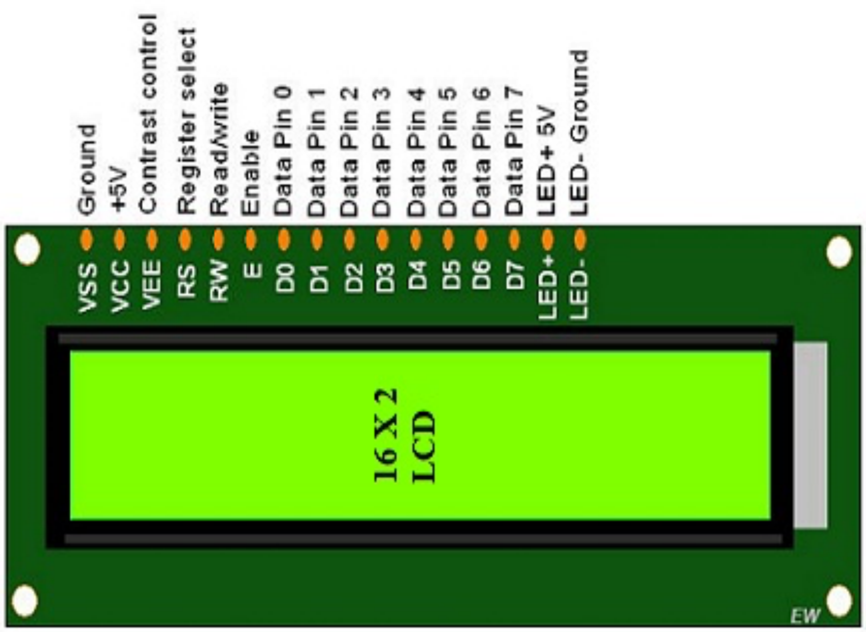

Fig. C2: LCD Pins

Pin No:	Pin Name:	Description
1	Vss (Ground)	Ground pin connected to system ground
2	Vdd (+5 Volt)	Powers the LCD with +5V (4.7V – 5.3V)
3	VE (Contrast V)	Decides the contrast level of display. Grounded to get maximum contrast.
4	Register Select	Connected to Microcontroller to shift between command/data register
5	Read/Write	Used to read or write data. Normally grounded to write data to LCD
6	Enable	Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement
7	Data Pin 0	Data pins 0 to 7 forms a 8-bit data line. They can be connected to Microcontroller to send 8-bit data. These LCD's can also operate on 4-bit mode in such case Data pin 4,5,6 and 7 will be left free.
8	Data Pin 1	Input Pins
9	Data Pin 2	
10	Data Pin 3	
11	Data Pin 4	
12	Data Pin 5	

13	Data Pin 6	
14	Data Pin 7	
15	LED Positive	Backlight LED pin positive terminal
16	LED Negative	Backlight LED pin negative terminal

Features of LCD16x2:

- 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

Advantages of liquid crystal display (LCD):

- The LCD can be made in large sizes of over 60 inch or 150 cm diagonal.
- It has no geometric distortion.
- It is very compact, thin, and light CRT displays.
- It does not affect by the magnetic fields.
- Due to low power consumption, small heat emitted during operation.
- It is much thinner than a CRT (cathode ray tube) monitor.

Disadvantages of liquid crystal display (LCD):

- In high temperature environments there is loss of contrast.
- It is relatively bright but not suitable for very brightly environments.
- It consumed a lot of electricity which produce a lot of heat.
- It has individual liquid crystals which cannot complete all block of the backlight.
- From the viewing angle, the color and contrast not consistent.

Appendix D

About LED:

A light-emitting diode (LED) is a semiconductor light source. LED’s are used as indicator lamps in many devices, and are increasingly used for lighting. Introduced as a practical electronic component in 1962, early LED’s emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness. The internal structure and parts of a led are shown in figures D.1 and D.2 respectively.

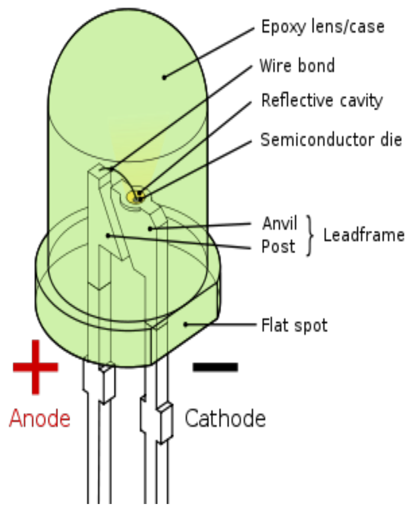

Fig D1: Parts of a LED

Working:

The structure of the LED light is completely different than that of the light bulb. Amazingly, the LED has a simple and strong structure. The light-emitting semiconductor material is what determines the LED's color. The LED is based on the semiconductor diode.

When a diode is forward biased (switched on), electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. An LED is usually small in area (less than 1 mm^2), and integrated optical components are used to shape its radiation pattern and assist in reflection. LED’s present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability. However, they are relatively expensive and require more precise current and heat management than traditional light sources. Current LED products for general lighting are more expensive to buy than fluorescent lamp sources of comparable output. They also enjoy use in applications as diverse as replacements for traditional light sources in automotive lighting (particularly indicators) and in traffic signals. The compact size of LED’s has allowed new text and video displays and sensors to be developed, while their high switching rates are useful in advanced communications technology. The electrical symbol and polarities of led are shown in fig: 2.3.3.

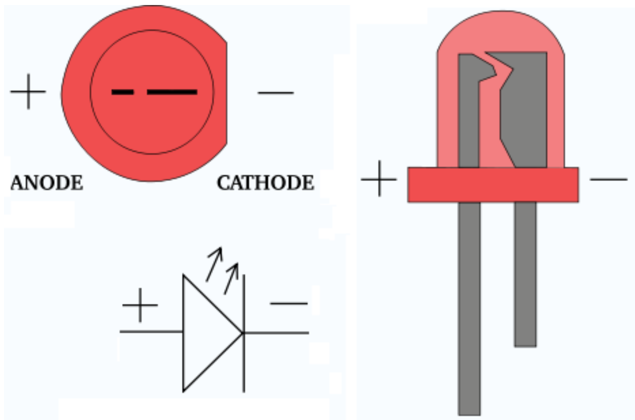

Fig .D2: Electrical Symbol & Polarities of LED

Advantages of LED:

- High-levels of brightness and intensity
- High-efficiency
- Low-voltage and current requirements
- Low radiated heat

High reliability (resistant to shock and vibration) Disadvantages of LED:

- High up-front costs
- Transformer compatibility
- Potential colour shift over lamp life
- Performance standardization has not yet been streamlined
- Overheating can cause reduced lamp life

Applications of LED:

- Visual signal application where the light goes more or less directly from the LED to the human eye, to convey a message or meaning.
- Illumination where LED light is reflected from object to give visual response of these objects.
- Generate light for measuring and interacting with processes that do not involve the human visual system.

(Appendix E) IR Transmitter and Receiver:

About:

IR pair is an electronic device which consists of two parts i) Transmitter and ii) Receiver. Transmitter is used to transmits or emit the INFRARED rays and the receiver is used simply to receive these radiations.

Fig. E1: IR TX and RX

How To distinguish Between these Two:

- Connect cathode of one LED to +ve terminal of DMM
- Connect anode of the same LED to common terminal of DMM
  (means connect LED such that It gets reverse biased by DMM)
- Set DMM to measure resistance upto 2M Ohm.
- Check the reading.
- Repeat above procedure with second LED.
- In above process, when you get the reading of the few hundred Kilo Ohms on DMM, then it indicated that LED that you are testing is IR sensor. In case of IR transmitter DMM will not show any reading.

Simple Testing Circuit:

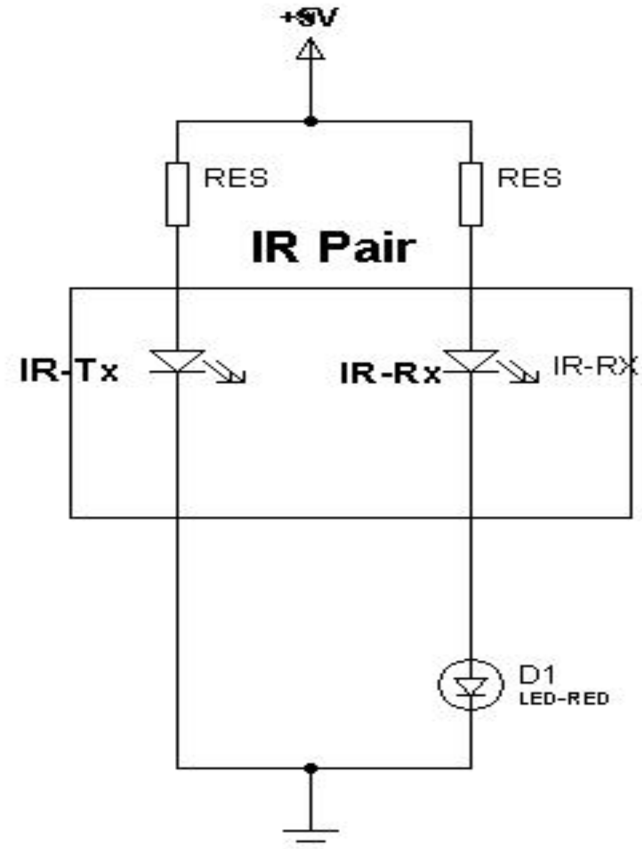

Fig. E2: IR pair Test Circuit

The pair should face each other in an Head to Head manner and the distance b/w these should be as minimum as possible , but please make sure that there should be a small clearance b/w pair.

Observe the Following:

- When there is no obstacle b/w the two the RED LED will start glowing.
- When there is an obstacle b/w the two the RED LED will stop glowing.

Features:

- Size: 5mm LED
- Wavelength: 940nm wavelength (most commonly used)
- 100 mA continuous, 1000 mA pulse
- Approx 1.6V forward voltage
- Applicaitons: build wireless remotes for appliances, distance sensors, object sensors, colour sensors, line sensors, distance sensors, etc

Appendix F

About Potentiometer:

A potentiometer (also known as a pot or potmeter) is defined as a 3 terminal variable resistor in which the resistance is manually varied to control the flow of electric current. A potentiometer acts as an adjustable voltage divide.

Working of Potentiometer:

A potentiometer is a passive electronic component. Potentiometers work by varying the position of a sliding contact across a uniform resistance. In a potentiometer, the entire input voltage is applied across the whole length of the resistor, and the output voltage is the voltage drop between the fixed and sliding contact as shown below.

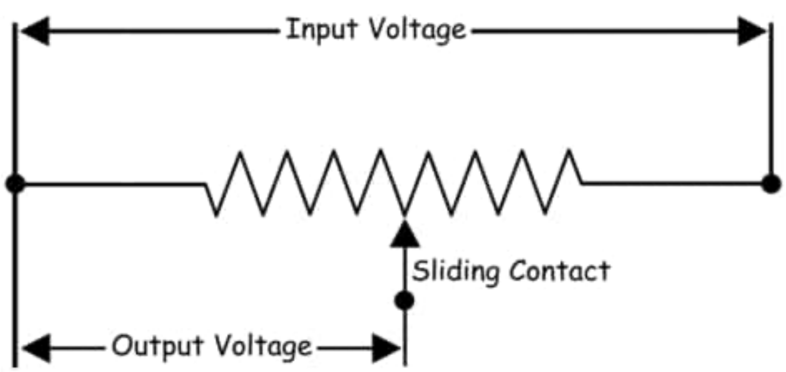

Fig. F1:

A potentiometer has the two terminals of the input source fixed to the end of the resistor. To adjust the output voltage the sliding contact gets moved along the resistor on the output side.
This is different to a rheostat, where here one end is fixed and the sliding terminal is connected to the circuit, as shown below.

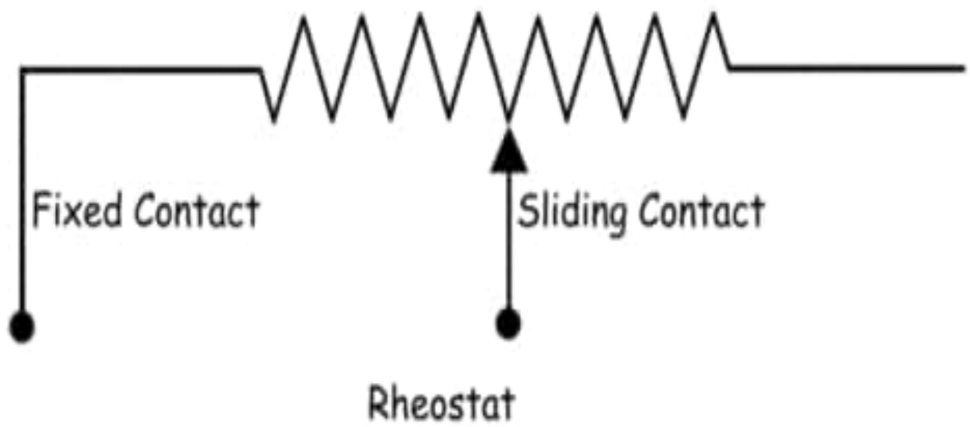

Fig. F2:

This is a very basic instrument used for comparing the emf of two cells and for calibrating ammeter, voltmeter, and watt-meter. The basic **working principle of a potentiometer** is quite simple. Suppose we have connected two batteries in parallel through a galvanometer. The negative battery terminals are connected together and positive battery terminals are also connected together through a galvanometer as shown in the figure below.

Potentiometer Types:

There are two main types of potentiometers:

- Rotary potentiometer
- Linear potentiometer

Although the basic constructional features of these potentiometers vary, the working principle of both of these types of potentiometers is the same.
Note that these are types of DC potentiometers – the types of AC potentiometers are slightly different.

Advantages of Digital Potentiometer:

- Higher reliability
- Increased accuracy
- Small size, multiple potentiometers can be packed on a single chip
- Negligible resistance drift
- Unaffected by environmental conditions like vibrations, humidity, shocks and wiper contamination
- No moving part
- Tolerance up to ±1%
- Very low power dissipation, up to tens of milliwatts

Disadvantages of Digital Potentiometers:

- Not suitable for high temperature environment and high power application.

- Due to the parasitic capacitance of the electronic switches, there is a bandwidth consideration that comes into the picture in **digital potentiometers**. It is the maximum signal frequency that can cross the resistance terminals with less than 3 dB attenuation in the wiper. The transfer equation is similar to that of a low pass filter.
- The nonlinearity in the wiper resistance adds a harmonic distortion to the output signal. The total harmonic distortion, or THD, quantifies the degree to which the signal is degraded after crossing through the resistance.

Applications of Potentiometer:

- Comparing the emf of a battery cell with a standard cell
- Measuring the internal resistance of a battery cell
- Measuring the voltage across a branch of a circuit

Appendix G

About Resistor:

Resistors are used in virtually all electronic circuits and many electrical ones. Resistors, as their name indicates resist the flow of electricity, and this function is key to the operation most circuits.
There are two main circuit symbols used for resistors. The oldest one is still widely used in North America and consists of a jagged line representing the wire used in a resistor. The other resistor circuit symbol is a small rectangle, and this is often termed the international resistor symbol and it is more widely used in Europe and Asia.

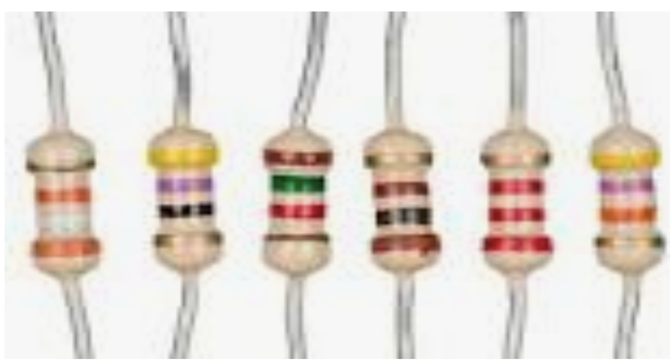

Fig. G1: Resistors

A passive electrical component with two terminals that are used for either limiting or regulating the flow of electric current in electrical circuits.
The main purpose of resistor is to reduce the current flow and to lower the voltage in any particular portion of the circuit.
The SI unit of resistor is Ohm.

Symbol of Resistor:

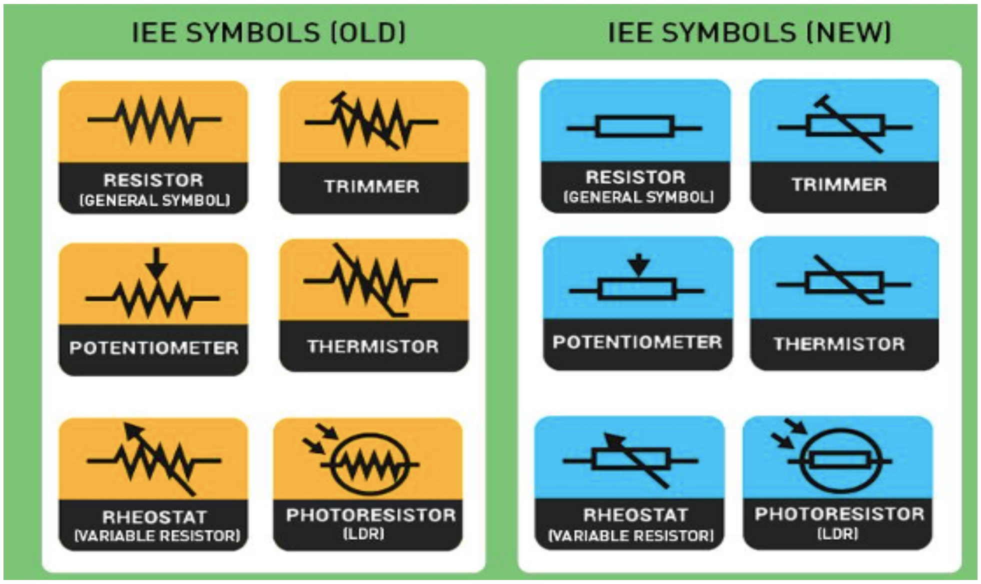

Fig. G2: Symbols of resistors

The terminals of the resistor are each of the lines extending from the squiggle (or rectangle). Those are what connect to the rest of the circuit. The resistor circuit symbols are usually enhanced with both a resistance value and a name. The value, displayed in ohms, is obviously critical for both evaluating and actually constructing the circuit.

Basic distinction of resistor types:

The first major categories into which the different types of resistor can be fitted is into whether they are fixed or variable. These different resistor types are used for different applications:

- **Fixed resistor**s:
  Fixed resistors are by far the most widely used type of resistor. They are used in electronics circuits to set the right conditions in a circuit. Their values are determined during the design phase of the circuit, and they should never need to be changed to "adjust" the circuit. There are many different types of resistor which can be used in different circumstances and these different types of resistor are described in further detail below.
- **Variable resistors:**
  These resistors consist of a fixed resistor element and a slider which taps onto the main resistor element. This gives three connections to the component: two connected to the fixed element, and the third is the slider. In this way the component acts as a variable potential divider if all three connections are used. It is possible to connect to the slider and one end to provide a resistor with variable resistance.

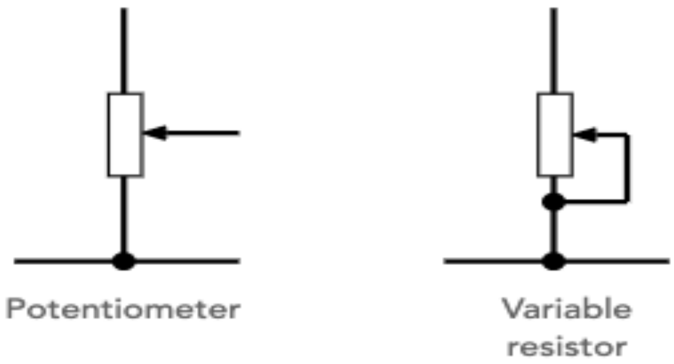

Fig. G3: Potentiometer & variable resistor

Strictly a potentiometer is a component where there is a fixed resistor which has a slider to provide a potential division from he voltage at the top. A variable resistor is effectively the same, but with the slider linked to one end of the resistor so that it provides a true variable resistance.

Colour Coding of Resistors:

Resistors may not display the value outside but resistor colour pattern through their resistance can be calculated. PTH (plated-through-hole) resistors use a color-coding system (which really adds some flair to circuits), and SMD (surface-mount-device)resistors have their own value-marking system. Following is a table with colour code of resistors:

Colour	**Colour code**
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

What is Tolerance in Resistors?

Colour	**Tolerance**
Brown	±1%
Red	±2%
Gold	±5%
Silver	±10%

ADVANTAGES:

- To control the current in a circuit, series connection is useful. On connecting the resistors in series the total circuit resistance increases and thus the current decreases.
- Damage of electrical appliance and short circuit can be prevented by connecting the fuse in series with the mains as well as the electrical appliance.

DISADVANTAGES:

- Series circuits have a single path that connects the electric source to the output devices. These circuits have limited uses because if a fault occurs in one appliance or the circuit breaks, the current does not flow in the circuit and all the other components in the circuit stop working.
- If the electrical appliances are connected in series, the applied voltage is divided and the appliance cannot give the light efficiently because of less voltage.

Applications of Resistor:

- Wire wound resistors find application where balanced current control, high sensitivity, and accurate measurement are required like in shunt with ampere meter.
- Photo resistors find application in flame detectors, burglar alarm, in photographic devices, etc.
- Resistors are used for controlling temperature and voltmeter.

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