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Design and Implementation of a smart solar cell Orientation system

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°c	: Celsius scale
°F	: Fahrenheit scale
I	: current
K	: Kelvin scale
K	: Sensor constant
R	: resistance
S	: sensitivity
T	: Ambient temperature.
T_h	: Hot temperature
T_c	: Cold temperature
ΔV	: Voltage difference between two dissimilar metals
η	: Efficiency
μC	: Microcontroller

List of abbreviations

AC	: Alternating current
ADC	: Analog to digital converter
AREF	: Analogue reference
A0	: Analog pin inside Arduino
CISC	: Complex instruction set computer
CPU	: Central processing unit
DAC	: Digital to analog converter
DC	: Direct current
GND	: Ground
ICSP	: In circuit serial programming
IC	: Integrated circuit.
IDE	: Integrated development environment
Int	: Integer
LDR	: Light dependent resistor
LED	: Light emitting diode
NTC	: Negative temperature coefficient
N-type	: Negative type
RAM	: Random access memory
RISC	: Reduced instruction set computer
PN	: Positive negative
ROM	: Read only memory
PT	: Platinum
PTC	: Positive temperature coefficient
PV	: Photovoltaic
P-type	: Positive type
PWM	: Pulse width modulation
RISC	: Reduced instruction set computer
RTD	: Resistance temperature detector.
Rx	: Receiver
SRAM	: Static random access memory
S0, S1, S2, S3	: Switches inside color sensor
TC	: Thermocouple

Tx	: Transmitter
UART	: Universal asynchronous receiver-transmitter
USB	: Universal serial bus

Abstract

The proposed project aims to design and implement a prototype for a smart farm base for installing the solar cells panels. This system has the ability to sense the solar light in the four basic directions all over the day hours. Accordingly, it detects the direction of the most intense solar illumination. Hence, it directs the installed solar panel to the detected direction for optimizing the harvested solar energy. Consequently, this auxiliary system enables the solar cell to achieve the maximum stored electrical energy in spite of the variation of the most intense solar illumination direction all over the day hours.

Four light dependent sensors (LDR) are used to sense the presence of the solar light in the four cardinal directions around the cell thus tracking the direction of maximum light intensity. Whereas, two servo motors are used for relocating the panel in the two perpendicular directions, horizontally and vertically. On the other hand, the Arduino platform is exploited for realizing the required control circuit.The smart farming will revolutionized the world of farming and it will increase the productivity as well as improve the quality and can save lives of farmer. There is an urgent need for a system that makes the agricultural process easier and burden free from the farmer's side and The ability to conserve the natural resources and use it with a solar panel, so that the entire system is eco-friendly. as well as giving a splendid boost to the production of the crops to save farmer's effort, water and time has been the most important consideration

Chapter 1

Introduction

During the last few years the renewable energy sources like solar energy have gained much importance in all over the world. Different types of renewable or green energy resources like hydropower, wind power, and biomass energy are currently being utilized for the supply of energy demand. Among the conventional renewable energy sources, solar energy is the most essential and prerequisite resource of sustainable energy.

Solar energy refers to the conversion of the sun's rays into useful forms of energy, such as electricity or heat. A photovoltaic cell, commonly called a solar cell or PV, is the technology used to convert solar energy directly into electrical power. The physics of the PV cell (solar cell) is very similar to the classical p-n junction diode. Sunlight is composed of photons or particles of solar energy. Semiconductor materials within the PV cell absorb sunlight which knocks electrons from their atoms, allowing electrons to flow through the material to produce electricity. Because of its cleanliness, ubiquity, abundance, and sustainability, solar energy has become well recognized and widely utilized.[2]

Different researches estimate that covering small area of the land on earth, nearly twice the world's consumption rate of fossil energy. This proves the potential of solar energy which in turn points out the necessity of tracking mechanism in solar systems. The tracking mechanism is an electromechanical system that ensures solar radiation is always perpendicular to the surface of the photovoltaic cells (solar cells) which maximizes energy harnessing.

Over the years, researchers have developed smart solar trackers for maximizing the amount of energy generation. Before the introduction of solar tracking methods, static solar panels were positioned with a reasonable tilted angle based on the latitude of the location.

There are mainly two types of solar trackers on the basis of their movement degrees of freedoms. These are single axis solar tracker and dual axis solar tracker. Again these two systems are further classified on the basis of their tracking technologies.

Researchers used single axis tracking system which follows only the sun's daily motion. But the earth follows a complex motion that consists of the daily motion and the annual motion. The daily motion causes the sun to appear in the east to west direction over the earth whereas the annual motion causes the sun to tilt at a particular angle while moving along east to west direction.

Solar tracking is best achieved when the tilt angle of the solar tracking systems is synchronized with the seasonal changes of the sun's altitude. An ideal tracker would allow the solar modules to point towards the sun, compensating for both changes in the altitude angle of the sun (throughout the day) and latitudinal offset of the sun (during seasonal changes). So the maximum efficiency of the solar panel is not being used by single axis tracking system whereas double axis tracking would ensure a cosine effectiveness of one.

In active tracking or continuous tracking, the position of the sun in the sky during the day is continuously determined by sensors. The sensors (LDR'S) will trigger the motor or actuator to move the mounting system so that the solar panels will always face the sun throughout the day. If the sunlight is not perpendicular to the tracker, then there will be a difference in light intensity on one light sensor compared to another. This difference can be used to determine in which direction the tracker has to be tilted in order to be perpendicular to the sun. This method of sun tracking is reasonably accurate except on very cloudy days when it is hard for the sensors to determine the position of the sun in the sky.[3]

To track the sun's movement accurately dual axis tracking system is necessary. The active tracking system tracks the sun for light intensity variation with precision. Hence, the power gain from this system is very high. But to achieve this power gain the system uses two different motors continuously for two different axes. As a result it always consumes a certain amount of extra power compared to time-based tracking system. Therefore to reduce this power loss a combination of active and time based tracking could be the suitable alternative to this system. Finally the motivation of the project was to design and implement a hybrid dual axis solar tracking system which reduces the motor power consumption while tracking accurately.

A simple energy efficient and rugged tracking model is presented is in order to build a hybrid dual axis solar tracker. To track the sun's daily motion, that is, from east to west direction, a pair of light sensors are used and to track the seasonal motion of the sun real time clock is used to create the accurate azimuth angle from some predetermined parameters. The light intensity is compared by microcontroller (Arduino Uno) and it generates the suitable control signals to move the motors in proper direction. Two servo motors are used for rotating the solar module in two different axes.

And take advantage of the output by storing it in batteries to be the income of another project, Proposals as an extension to our project could have been used **Wireless electricity** transfer simply the transmission of energy from one place to another without using wires via resonant inductive coupling between the transmitting and receiving coils in the near field. To demonstrate that power is successfully transferred wirelessly, an LED and a DC battery is used, is a process to supply power through an air gap without using any wires or physical link. In this wireless system, the transmitter device generates a time-varying or high-frequency electromagnetic field, which transmits power to receiver device without any physical connection. The receiver device extracts power from the magnetic field and supplies it to electrical load. Therefore, to convert the electricity to an electromagnetic field, two coils are used as transmitter coil and receiver coil. The transmitter coil is powered by alternating current and creates a magnetic field, which is further converted into a usable voltage across the receiver coil.to improve the transmission distance, wind up the coil properly and increase the no. of turns in the coil, Or used **Simple Metal detector** circuits are portable electronic devices for finding the presence of any metal within close range for example for the safety of people to detect anyone carrying a metal.. These instruments function by sensing changes in magnetic waves caused by being in near proximity to a metallic object.

it is a circuit that determines the place in which a type of metal such as iron, copper, aluminum, etc. is located, as it emits a fixed-tone sound, and when the coil in it passes with a mineral, a change occurs in this tone, which indicates the presence of a metal in the place it passed through, operate by transmitting an electromagnetic field from the search coil to the ground. Any metallic objects that are within the electromagnetic field get energize and retransmit an electromagnetic field of their own. The search coil receives this electromagnetic retransmitted field and sounds an alert.[5]

But we are already done **Smart farm**, the farming is important for life of most countries in the world and has influence on the economy. In dry or in case of inadequate rainfall areas the irrigation become difficult, Farmers tend to over-irrigation the soil. Different kinds of soil required different irrigation schedules and the irrigation also depends on many other factors like wind speed, existing moisture level, temperature season, stage of growth of crop, etc.

Smart farm consist of automated irrigation system with programmable schedule, automatic tank level controlling for storage water of irrigation, and temperature measurement of farm based microcontroller with desired sensors and network server (gateway) which was connected to the internet.

Smart Farming can be adapted to support any type of farm, from control of what happens and monitoring of the various processes. This includes solutions from monitoring environments, using a user-friendly application on a smart phone or tablet, all events on the farm can be monitored and controlled.

Chapter 2

Microcontroller

A microcontroller (μC or uC) is a single microcomputer chip manufactured from VLSI manufacturing. The microcontroller is also known as the built-in controller. Various types of microcontrollers are now available on the market with various word lengths, such as 4bit, 8bit, 64bit and 128bit microcontrollers. Microcontroller is a compressed microcomputer built to monitor the functions of embedded systems in office machines, robots, home appliances, motor vehicles and a number of other gadgets.The microcontroller consists of components such as memory, peripherals and most importantly, a processor. Microcontrollers are basically used in systems that require a degree of control to be applied by the computer consumer [1].

2.1 Microcontroller basics

Any electric appliance that stores, measures, displays information or calculates comprise of a microcontroller chip inside it. The basic structure at figure 2.1 of a microcontroller comprise of:

Processor Core: The CPU of the controller. It contains the arithmetic logic unit, the control unit, and the registers (stack pointer, program counter, accumulator register, register file, . . .) [1].

Memory: The memory is sometimes split into program memory and data memory. In larger controllers, a DMA controller handles data transfers between peripheral components and the memory [1].

Input/output ports: The I/O Ports provide the interface for the

Microcontroller to the external world. Input devices, such as switches, keypads, etc., provide the CPU with user information in the form of binary data [1].

Upon receiving the information from the input devices, the CPU executes appropriate instructions and responds through output devices such as LEDs, displays, printers [1].

Serial Ports: These ports give serial interfaces a mid microcontroller& various other peripherals such as parallel port[1].

Timer/Counter: Most controllers have 2-3 Timers/Counters at least one and more likely, which can be used to time stamp events, calculate intervals, or count events [1].

There are also PWM (pulse width modulation) outputs in several controllers that can be used to drive motors or for safe breakage (antilock brake system, ABS). In addition, in combination with an external filter, the PWM output can be used to create a cheap digital/analog converter [1].

ADC (Analog to digital converter): ADC is employed to convert analog signals to digital ones. The input signals need to be analog for ADC. The digital signal production can be employed for different digital applications (such as measurement gadgets)[1].

DAC (digital to analog converter): this converter executes opposite functions that ADC perform. This device is generally employed to supervise analog appliances like DC motors [1].

RAM (Random access memory): The data **RAM** (Random Access Memory) is the data space that is used for temporarily storing constant and variable values that are used by the microcontroller during normal program execution. The amount of physical RAM space on a given microcontroller varies from one microcontroller to the next [1].

ROM (Read only memory): The on chip **ROM** memory (Read Only Memory) on a microcontroller is like a microcontroller's hard drive. One partition is reserved for the storage of the program code while the other partition is reserved for permanent storage of data that is used by the chip during normal program execution [1].

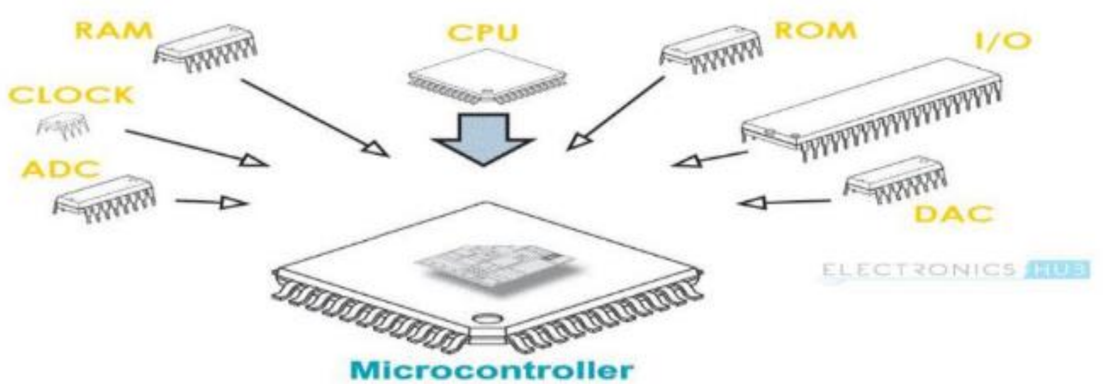


Figure2.1: Elements of microcontroller

2.2 Classification of microcontrollers

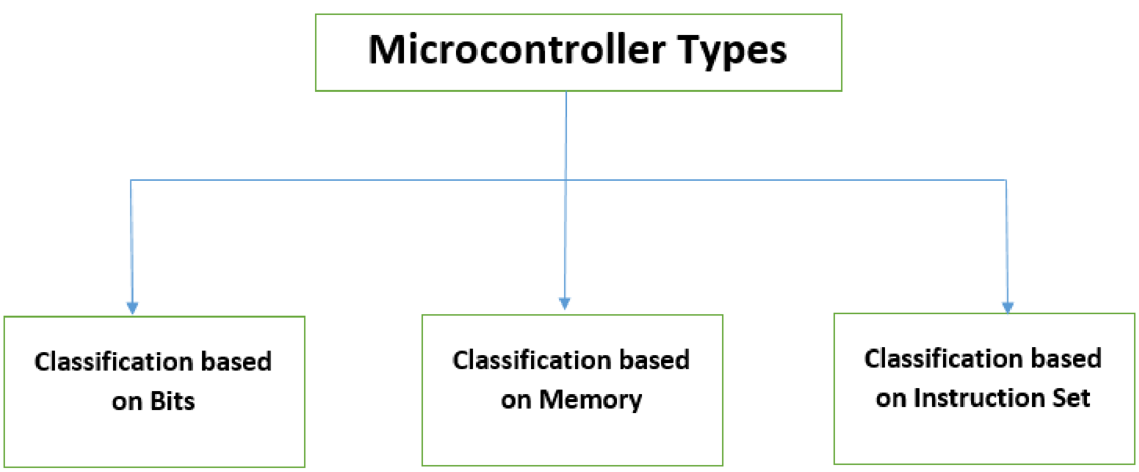


Figure2.2: Types of Microcontrollers

2.2.1 Classification based on bits

- **A microcontroller of 8 bits**: performs logic & arithmetic operations. The Intel 8031/8051 is an example of an 8-bit micro controller [2].
- In comparison to 8-bit, **the 16-bit microcontroller** operates with greater precision and performance. Intel 8096 is an example of a 16-bit microcontroller [1].
- **The 32-bit microcontroller** is primarily used in devices that are automatically operated, such as office machines and implantable medical devices. In order to perform some logical or arithmetic operation, it needs 32 bit instructions [2].

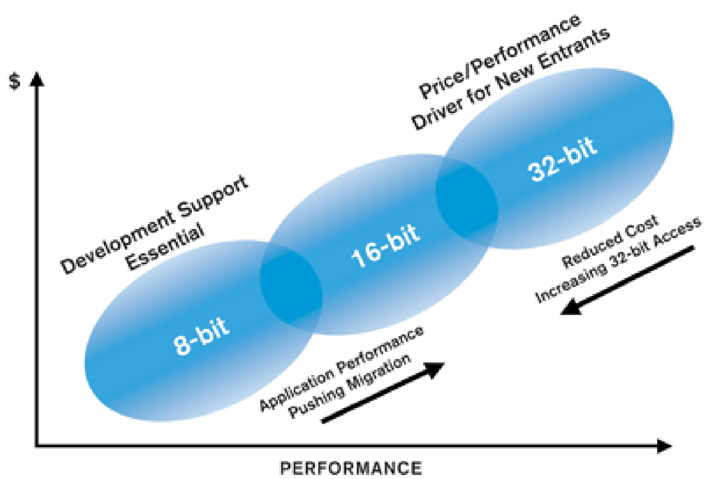


Figure 2.3: Performance and cost of 8,16,32 bit microcontrollers

2.2.2 Classification based on memory

External Memory Microcontroller: This is called an external memory microcontroller if an embedded structure is designed with a microcontroller that doesn't have all the accessible blocks on the chip. The 8031 microcontroller, for instance, does not have programming memory on the chip [2].

Embedded Memory Microcontroller: When a microcontroller consisting of all functional blocks on a chip is designed with an embedded structure, it is called an embedded memory microcontroller. For example, the 8051 microcontroller has all programming & data memory, counters & timers, interrupts, I/O ports and hence its built-in memory microcontroller[2].

2.2.3 Classification based on instruction set

CISC: CISC implies a complicated computer set of instructions, enabling the user to add one instruction as an alternative to several easy instructions [2].

RISC: RISC means Computers with a Reduced Instruction Set. By shortening the clock cycle per instruction, RISC decreases the operation time[2].

2.3 Arduino

Arduino at figure 2.4 is a prototyping platform for open source electronics based on simple hardware and software to use[3].

Arduino is a prototyping board based on a microcontroller that can be used to create digital devices that can read inputs such as a finger on a button, a touch on a screen, a light on a sensor and translate it into outputs such as flipping on an LED spinning motor, playing songs through speaker[3].

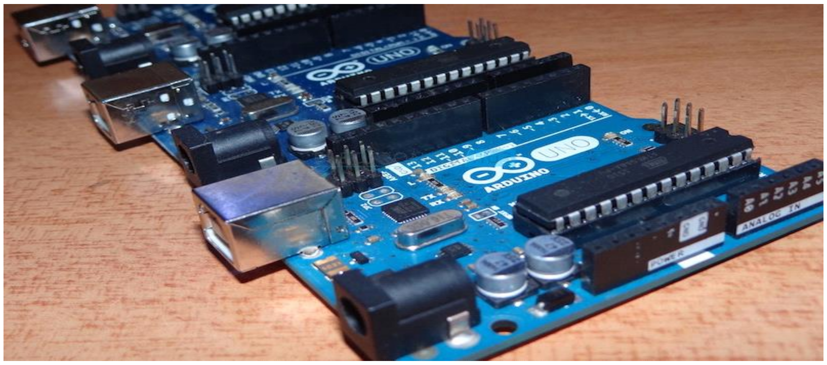


Figure2.4: Arduino board

By simply programming the microcontroller on board, the Arduino board can be programmed to do something, using a set of instructions for which the Arduino board consists of a USB plug to communicate with your computer and a bunch of link sockets that can be connected to external devices such as motors, LEDs. Arduino's goal is to bring people with little to no background in electronics, such as hobbyists, designers, musicians, to the world of electronics[3].

2.3.1 Hardware and software

Arduino boards are typically based on Atmel Corporation microcontrollers, such as microcontrollers based on the 8, 16 or 32 bit AVR architecture[3].

Standard connectors are a significant aspect of Arduino boards. We may link the Arduino board to other devices, such as LEDs, using these connectors, or add modules called Shields[3].

The Arduino boards also have a voltage regulator and a crystal oscillator on the board. They also consist of USB to serial adapters that can be programmed using a USB link to the Arduino board[3].

We need to use the IDE supplied by Arduino in order to programming the Arduino board. The Arduino IDE is based on the programming language Processing and supports C and C++ [3].

2.4 Difference between Arduino and microcontrollers

Table 2.1: Difference between Arduino and microcontroller

Microcontroller	**Arduino**
Microcontrollers at figure 2.5 are the ones, which control the things. Micro is for it's size , not for it's computational power. Microcontrollers takes input, process it and according to that gives output.	Arduino at figure 2.6 is such a board, and contains a microcontroller, typical an 8-bit AVR such as the ATmega8,ATmega168, ATmega328, ATmega1280, and ATmega2560, plus power supplies, crystal, and female headers to interface with various peripheral boards.
 **Figure2.5: Microcontroller**	 **Figure 2.6: Arduino board**

2.5 Types of Arduino boards

There are several types of Arduino boards shown in figure 2.7 available on the market, but all boards have one thing in common: using the Arduino IDE they can be programmed. The reasons for different board types are different specifications for power supply, networking choices, their applications.

Arduino boards are available in various sizes, form factors, various I/O pin numbers. Arduino UNO, Arduino Super, Arduino Nano and Arduino Micro are some of the well recognized and regularly used Arduino boards.

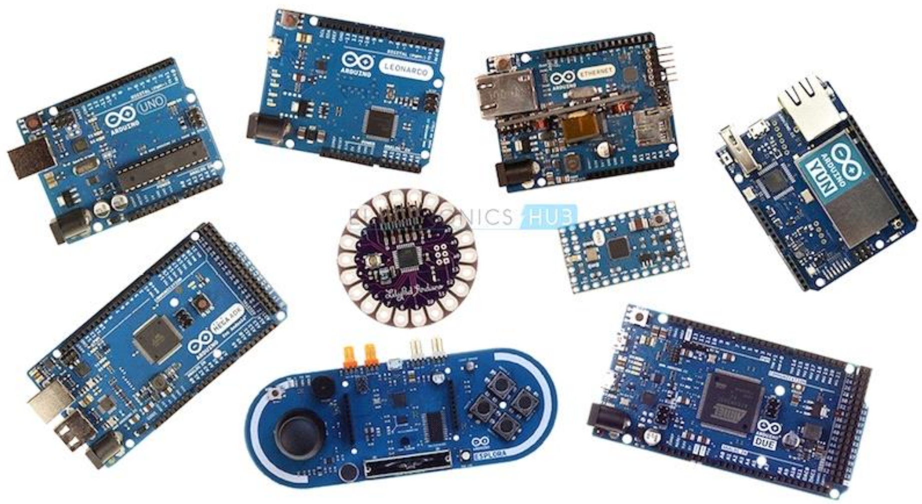


Figure2.7: Arduino boards

2.5.1 Arduino Nano

The Arduino Nano at figure 2.8 is a very small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.0). Arduino Nano board is very suitable for applications where small and compact size is important for user [4].

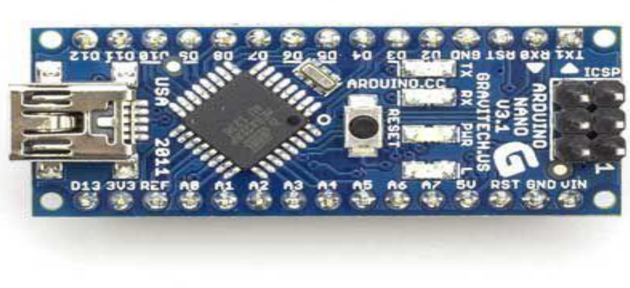


Figure 2.8: Arduino Nano

2.5.2 Arduino Mega

The ATmega2560 based microcontroller module is the Arduino Super at figure 2.9. It has 54 digital input/output pins, 16 analogue inputs, 4 hardware serial ports (UARTs), a 16 MHz crystal oscillator, a USB connection, an ICSP header, a power jack and a reset button (of which 14 can be used as PWM outputs). It includes everything you need to help the microcontroller; just connect it to a device with a USB cable [4].

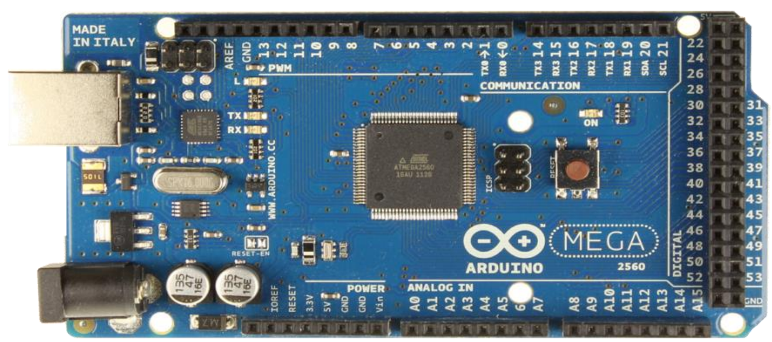


Figure 2.9: Arduino Mega

2.5.3 Arduino Micro

The Arduino Micro at figure 2.10 is a microcontroller board based on the ATmega32u4. It has 20 digital input/output pins (of which 7 can be used as PWM outputs and 12 as analog inputs), a 16 MHz crystal oscillator, a micro USB connection, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a micro USB cable to get started[4].

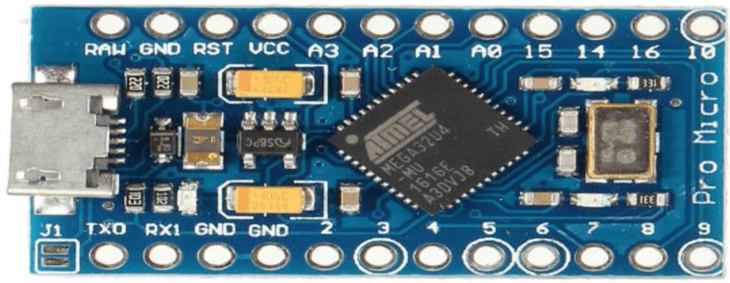


Figure 2.10: Arduino Micro

2.5.4 Arduino leonardo

The basic specification of the Arduino Leonardo shown at figure 2.11 is the same as the Arduino Micro. It is also based on ATmega32U4 Microcontroller. The components present on the board are 20 analog and digital pins, reset button, 16MHz crystal oscillator, ICSP header, and a micro USB connection [4].

Figure 2.11: Arduino leonardo

2.5.5 Arduino Due

The Arduino Due at figure 2.12 is based on the 32- bit ARM core. It is the first Arduino board that has developed based on the ARM Microcontroller. It consists of 54 Digital Input /Output pins and 12 Analog pins. The Microcontroller present on the board is the Atmel SAM3X8E ARM Cortex-M3 CPU[4].

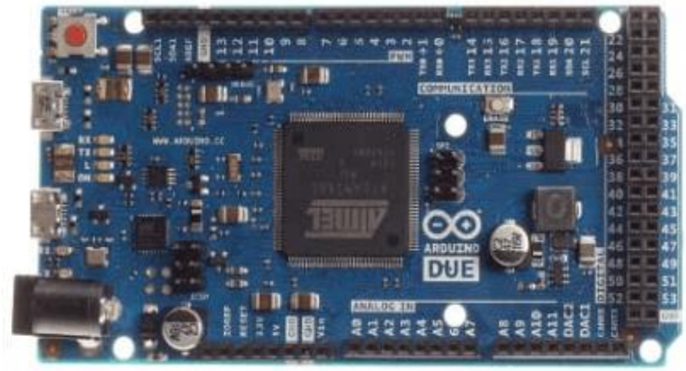


Figure 2.12: Arduino Due

It has two ports, namely, native USB port and Programming port. The micro side of the USB cable should be attached to the programming port[4].

2.5.6 Arduino Lilypad

The Arduino LilyPad shown in figure 2.13 was initially created for wearable projects and e-textiles. It is based on the ATmega168 Microcontroller. The functionality of Lilypad is the same as other Arduino Boards. It is a round, light-weight board with a minimal number of components to keep the size of board small. The Arduino Lilypad board has 9 digital I/O pins [4].

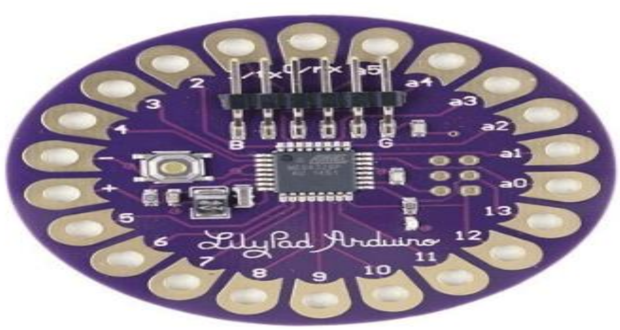


Figure 2.13: Arduino Lilypad

2.5.7 Arduino Esplora

The Arduino Esplora at figure 2.14 boards allow easy interfacing of sensors and actuators. The outputs and inputs connected on the Esplora board make it unique from other types of Arduino boards. The board includes outputs, inputs, a small microcontroller, a microphone, a sensor, a joystick, an accelerometer, a temperature sensor, four buttons, and a slider [4].

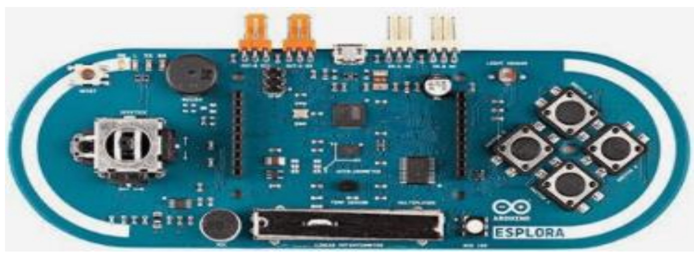


Figure 2.14: Arduino Esplora

2.5.8 Arduino pro micro

The structure of Arduino Pro Micro shown in figure 2.15 is similar to the Arduino Mini board, except the Microcontroller ATmega32U4. The board consists of 12 digital Input/output pins, 5 PWM (Pulse Width Modulation) pins, Tx and Rx serial connections, and 10-bit ADC (Analog to Digital Converter [4].

Figure 2.15: Arduino pro micro

2.6 Arduino UNO

The Arduino Uno at figure 2.16 is an 8-bit ATmega328 microcontroller-based microcontroller module. In addition to the ATmega328, the microcontroller is provided by other components such as the crystal oscillator, serial communication, voltage regulator, etc. There are 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog input pins, a USB link, a power barrel jack, an ICSP header, and a reset button [4].

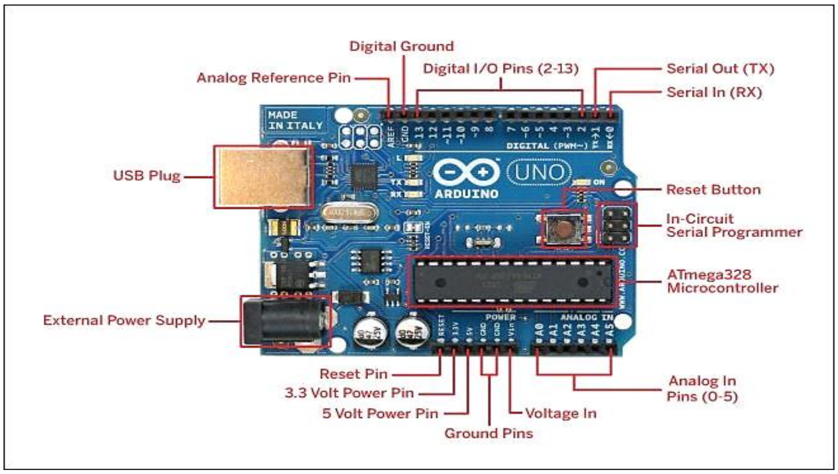


Figure 2.16: Arduino UNO board

The microcontroller used in the project is Arduino UNO. Arduino Uno is the most standard board available and probably the best choice for a beginner, It is a good all purpose board that has enough features for a beginner to get started with. Some of its better features are:

1. Its biggest advantage is that we connect the board to the computer via a USB cable which does a dual purpose of supplying power and acting as a Serial port to interface the Arduino and the computer.
2. The ATmega328 chip can be newly bought, removed and replaced if damaged which is not possible with other versions.

3. The board operates at 5V throughout, i.e. digital pins output or read 5v and analog pins read in the range 0-5V.
4. The Uno features 14 Digital I/O pins and 6 Analog I/O pins.
5. It is the cheapest board with all these features.

Table2.2: Comparison between Arduino boards

Basics of comparison	Leonardo	Micro	Nano	Mega	Due	Esplora	Lilypad	Pro micro	Uno
Flash memory	32KB	32KB	32KB	256KB	512KB	32KB	32KB	32KB	32KB
SRAM	2.5KB	2.5KB	2KB	8KB	96KB	2.5KB	2KB	2.5KB	2KB
Digital I/O pins	20	20	14	54	54	14	9	12	14
Analog input pins	12	12	8	16	12	7	4	9	6
Crystal oscillator (MHZ)	16	16	16	16	84	16	8	16	16
Operating voltage	5v	5v	5v	5v	3.3v	5v	5.5v	12v	5v

2.6.1 THE ATMEGA 328P Atmel 8bits 32k AVR microcontroller

The Atmel®picoPower®ATmega328/P at figure 2.17 is a low power CMOS 8 bit microcontroller based on the AVR® enhanced RISC architecture.

Figure 2.17: PIN DIAGRAM

- **PIN Layout of ATMEGA328P is showed below:**

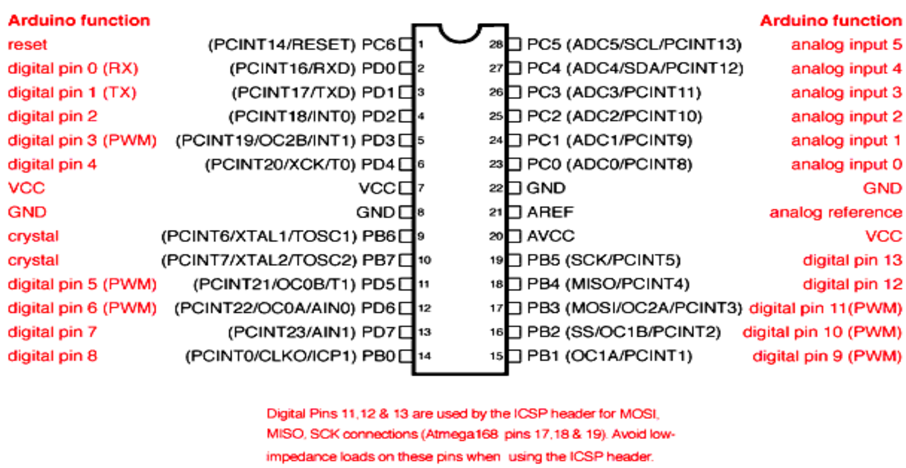


Figure 2.18: PIN Layout of ATMEGA328P

2.6.2 Pin description of Arduino Uno

Table 2.3: Description of Arduino Uno pins

Pin category	Pin Name	Description

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 pins at 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)0	Used to transmit and receive TTL serial data. They are connected with the corresponding ATmega328P USB to TTL serial chip.
External interrupts	2,3	To trigger an interrupt
PWM	3,5,6,9,11	Provides 8 bit PWM output analog Write () function.
SPI	10(SS),11(MOSI),12(MISO)and 13(SCK)	Used for SPI communication
Inbuilt LED	13	This pin is connected with an built-in LED, when pin 13 is HIGH LED is on and when pin 13 is LOW, its off.
AREF	AREF	To provide reference voltage for input voltage

2.6.3 Arduino Uno technical specifications

Table 2.4: Technical specifications of Arduino Uno

Microcontroller	**ATmega328P – 8 bit AVR family microcontroller**
Operating voltage	5v
Recommended input voltage	7-12v
Input voltage limits	6-20v
Analog input voltage	6(A0-A5)
Digital I/O pins	14(out of which 6 provide PWM output)
DC currents on I/O pins	40mA
DC currents on 3.3v	50MA
Flash memory	32KB
SRAM	2KB
EEPROM	1KB
Frequency(clock speed)	16MHz

2.6.4 Programming of Arduino Uno

Use a USB cable to connect the Arduino board to your device once the Arduino IDE tool is mounted on the PC. Open the Arduino IDE and pick the correct board by selecting Tools->Board..>Arduino Uno and choosing Tools->Port to select the right port. Depending on wiring, this board can be programmed with the help of an Arduino programming language [4].

2.6.5 ADC

Figure 2.19: ADC input channels in Arduino Uno

The Arduino Uno board at figure 2.19 has 6 ports of ADC input. Among these, any or all of them can be used as analogue voltage inputs. The 10 bit resolution of the Arduino Uno ADC (so the integer values are from (0-(2^10) 1023)). This implies that input voltages between 0 and 5 volts will be converted to integer values between 0 and 1023.

The default reference value of the UNO ADC channels is 5V. This implies that at any input channel, we can give a maximum input voltage of 5V for ADC conversion. Since some sensors have 0-2.5V voltages, we get less precision with a 5V reference, so we have an instruction that allows us to adjust this reference value. So we have ("analogue reference ();") for modifying the reference value.

As default we get the maximum board ADC resolution which is 10bits, this resolution can be changed by using instruction ("analog Read Resolution (bits);")

2.7 Applications on Arduino Uno

The most economical and inexpensive board is Arduino UNO. So a wide number of applications are supported by this board. Some important applications that are developed using Arduino UNO are:

- Embedded system
- Robotics
- Motion control rig
- DC motor control (using H-bridge)
- Defense and security defense
- Parking lot counter
- Home and industrial automation
- Water quality testing
- Data loggers (used in scientific research)
- open-source oscilloscope
- Count down timer for traffic lights

2.8 Arduino Language

2.8.1 Structure

The basic structure of the Arduino programming language is fairly simple and runs in at least two parts. These two required parts, or functions, enclose blocks of statements [4].

```
void setup()

{
```

```
statements;

}

void loop()

{

statements;

}
```

Where setup () is the preparation, loop() is the execution. Both functions are required for the program to work. The setup function should follow the declaration of any variables at the very beginning of the program. It is the first function to run in the program, is run only once, and is used to set pin Mode or initialize serial communication [4].

The loop function follows next and includes the code to be executed continuously reading inputs, triggering outputs. This function is the core of all Arduino programs and does the bulk of the work [4].

2.8.1.1 setup()

The setup() function is called once when your program starts. Use it to initialize pin modes, or begin serial. It must be included in a program even if there are no statements to run.

```
 Void setup()

{
```

Pin Mode (pin, OUTPUT); // sets the 'pin' as output

}

2.8.1.2 Loop()

After calling the setup() function, the loop() function does precisely what its name suggests, and loops consecutively, allowing the program to change, respond, and control the Arduino board[4].

```
void loop()

{

digital Write(pin, HIGH); // turns 'pin' on

delay(1000); // pauses for one second

digital Write(pin, LOW); // turns 'pin' off

delay(1000); // pauses for one second

}
```

2.8.1.3 Functions

A function is a block of code that has a name and a block of statements that are executed when the function is called. The functions void setup () and void loop() have already been discussed and other built in functions will be discussed later. Custom functions can be written to perform repetitive tasks. Functions are declared by first declaring the function type. This is the type of value to be returned by the function such as 'int' for an integer type function. If no value is to be returned the function type would be void. After type, declare the name given to the function and in parenthesis any parameters being passed to the function[4].

```
type function Name(parameters)

{

statements;

}
```

The following integer type function delay Val() is used to set a delay value in a program by reading the value of a potentiometer. It first declares a local variable v, sets v to the value of the potentiometer which gives a number between 0-1023, then divides that value by 4 for a final value between 0-255, and finally returns that value back to the main program[4].

```
int delay Val()

{

int v; // create temporary variable 'v'

v = analog Read(pot); // read potentiometer value

v /= 4; // converts 0-1023 to 0-255

v; // return final value

}
```

Curly braces (also referred to as just "braces" or "curly brackets") define the beginning and end of function blocks and statement blocks such as the void loop () function and the for and if statements.

```
type function ()
{
statements;
}
```

An opening curly brace { must always be followed by a closing curly brace }. This is often referred to as the braces being balanced.

2.8.1.4 (;) semicolon

A semicolon must be used to end a statement and separate elements of the program. A semicolon is also used to separate elements in a for loop.

```
int x = 13; // declares variable 'x' as the integer 13
```

Forgetting to end a line in a semicolon will result in a compiler error. The error text may be obvious, and refer to a missing semicolon, or it may not. If an impenetrable or seemingly illogical compiler error comes up, one of the first things to check is a missing semicolon, near the line where the compiler complained [4].

2.8.1.5 // line comments

Single line comments begin with // and end with the next line of code. Like block comments, they are ignored by the program and take no memory space [4].

```
// this is a single line comment
```

Single line comments are often used after a valid statement to provide more information about what the statement accomplishes or to provide a future reminder [4].

2.8.2 Data types

2.8.2.1 byte

Byte stores an 8-bit numerical value without decimal points. They have a range of 0-255[4].

```
byte some Variable = 180; // declares 'some Variable'
                    // as a byte type
```

2.8.2.2 int

Integers are the primary datatype for storage of numbers without decimal points and store a 16-bit value with a range of 32,767 to -32,768[4].

```
int some Variable = 1500; // declares 'some Variable'
                   // as an integer type
```

2.8.2.3 long

Extended size datatype for long integers, without decimal points, stored in a 32-bit value with a range of 2,147,483,647 to -2,147,483,648 [4].

```
long some Variable = 90000; // declares 'some Variable'
                    // as a long type
```

2.8.2.4 float

A datatype for floating-point numbers, or numbers that have a decimal point. Floating-point numbers have greater resolution than integers and are stored as a 32-bit value with a range of 3.4028235E+38 to -3.4028235E+38 [4].

```
float some Variable = 3.14; // declares 'some Variable'
                  // as a floating-point type
```

2.8.3 Arithmetic

Arithmetic operators include addition, subtraction, multiplication, and division. They return the sum, difference, product, or quotient (respectively) of two operands[4].

```
y = y + 3;

x = x - 7;

i = j * 6;

r = r / 5;
```

2.8.3.1 compound Assignment

Compound assignments combine an arithmetic operation with a variable assignment. These are commonly found in for loops as described later. The most common compound assignments include:

x ++ // same as x = x + 1, or increments x by +1

x -- // same as x = x - 1, or decrements x by -1

x += y // same as x = x + y, or increments x by +y

x -= y // same as x = x - y, or decrements x by -y

x *= y // same as x = x * y, or multiplies x by y

x /= y // same as x = x / y, or divides x by y

2.8.3.2 Comparison operators

Comparisons of one variable or constant against another are often used in if statements to test if a specified condition is true[4].

x = = y // x is equal to y

x != y // x is not equal to y

x < y // x is less than y

x > y // x is greater than y

x <= y // x is less than or equal to y

x >= y // x is greater than or equal to y

2.8.3.3 Logical operators

Logical operators are usually a way to compare two expressions and return a TRUE or FALSE depending on the operator. There are three logical operators, AND, OR, and NOT, that are often used in if statements:

Logical AND: if (x > 0 && x < 5) // true only if both

// expressions are true

Logical OR: if (x > 0 || y > 0) // true if either

// expression is true

Logical NOT: if (!x > 0) // true only if // expression is false

2.8.4 Flow control

2.8.4.1 If statement

if statements test whether a certain condition has been reached, such as an analog value being above a certain number, and executes any statements inside the brackets if the statement is true. If false the program skips over the statement. The format for an if test is:

if (some Variable ?? value) { do Something; }

The above example compares some Variable to another value, which can be either a variable or constant. If the comparison, or condition in parentheses is true, the statements inside the brackets are run. If not, the program skips over them and continues on after the brackets [4].

Beware of accidentally using '=', as in if(x=10), while technically valid, defines the variable x to the value of 10 and is as a result always true. Instead use '= =', as in if(x= =10), which only tests whether x happens to equal the value 10 or not. Think of '=' as "equals" opposed to '= =' being "is equal to" [4].

2.8.4.2 If... else

If... else allows for 'either-or' decisions to be made. For example, if you wanted to test a digital input, and do one thing if the input went HIGH or instead do another thing if the input was LOW, you would write that this way:

```
if (input Pin == HIGH)
{
do Thing A;
}
else
{
do Thing B;
 }
```

else can also precede another if test, so that multiple, mutually exclusive tests can be run at the same time. It is even possible to have an unlimited number of these else branches. Remember though, only one set of statements will be run depending on the condition tests:

```
if (input Pin < 500)
{
```

```
do Thing A;
}
else if (input Pin >= 1000)
{
do Thing B;
} else
{
do Thing C;
}
```

An if statement simply tests whether the condition inside the parenthesis is true or false. This statement can be any valid C statement as in the first example, if (input Pin = = HIGH). In this example, the if statement only checks to see if indeed the specified input is at logic level high, or +5v [4].

2.8.4.3 While

While loops will loop continuously, and infinitely, until the expression inside the parenthesis becomes false. Something must change the tested variable, or the while loop will never exit. This could be in your code, such as an incremented variable, or an external condition, such as testing a sensor [4].

```
while (some Variable ?? value)
{
do Something;
}
```

The following example tests whether 'some Variable' is less than 200 and if true executes the statements inside the brackets and will continue looping until 'some Variable' is no longer less than 200 [4].

```
 while (some Variable < 200) // tests if less than 200
{
do Something; // executes enclosed statements some Variable++;
            // increments variable by 1
}
```

2.8.4.4 Do... while

The do loop is a bottom driven loop that works in the same manner as the while loop, with the exception that the condition is tested at the end of the loop, so the do loop will always run at least once[4].

```
 do
{
do Something;
}
while (some Variable ?? value);
```

The following example assigns read Sensors() to the variable 'x', pauses for 50 milliseconds, then loops indefinitely until 'x' is no longer less than 100:

```
do
{
x = read Sensors (); // assigns the value of
               // read Sensors () to x
delay (50);      // pauses 50 milliseconds
} while (x < 100); // loops if x is less than 100
```

2.8.5 Constants

The Arduino language has a few predefined values, which are called constants. They are used to make the programs easier to read. Constants are classified in groups [4].

2.8.5.1 true/false

These are Boolean constants that define logic levels. FALSE is easily defined as 0 (zero) while TRUE is often defined as 1, but can also be anything else except zero. So in a Boolean sense, -1, 2, and -200 are all also defined as TRUE [4].

```
 if (b == TRUE);
{
do Something;
}
```

2.8.5.2 high/low

These constants define pin levels as HIGH or LOW and are used when reading or writing to digital pins. HIGH is defined as logic level 1, ON, or 5 volts while LOW is logic level 0, OFF, or 0 volts [4].

```
digital Write(13, HIGH);
```

2.8.5.3 input/output

Constants used with the pin Mode () function to define the mode of a digital pin as either INPUT or OUTPUT.

```
Pin Mode(13, OUTPUT);
```

2.8.6 Digital I/O

2.8.6.1 digital Write(pin, value)

Outputs either logic level HIGH or LOW at (turns on or off) a specified digital pin. The pin can be specified as either a variable or constant (0-13) [4].

Digital Write(pin, HIGH); // sets 'pin' to high

The following example reads a pushbutton connected to a digital input and turns on an LED connected to a digital output when the button has been pressed:

```
int led = 13; // connect LED to pin 13
int pin = 7; // connect pushbutton to pin 7
int value = 0; // variable to store the read value
void setup()
{
Pin Mode(led, OUTPUT); // sets pin 13 as output
pin Mode(pin, INPUT); // sets pin 7 as input
}
void loop()
{
value = digital Read(pin); // sets 'value' equal to // the input pin digital Write(led, value); // sets 'led' to the
}
```

2.8.6.2 digital Read(pin)

Reads the value from a specified digital pin with the result either HIGH or LOW. The pin can be specified as either a variable or constant (0-13)[4].

```
value = digital Read(Pin); // sets 'value' equal to
                    // the input pin
```

2.8.7 Analog I/O

2.8.7.1 Analog Read (pin)

Reads the value from a specified analog pin with a 10-bit resolution. This function only works on the analog in pins (0-5). The resulting integer values range from 0 to 1023[4].

value = analog Read(pin); // sets 'value' equal to 'pin'

Analog pins unlike digital ones, do not need to be first declared as INPUT nor OUTPUT.

2.8.7.2 Analog Write (pin ,value)

analog Write (pin, value); // writes 'value' to analog 'pin'

A value of 0 generates a steady 0 volts output at the specified pin; a value of 255 generates a steady 5 volts output at the specified pin. For values in between 0 and 255, the pin rapidly alternates between 0 and 5 volts - the higher the value, the more often the pin is HIGH (5 volts) [4].

For example, a value of 64 will be 0 volts three-quarters of the time, and 5 volts one quarter of the time; a value of 128 will be at 0 half the time and 255 half the time; and a value of 192 will be 0 volts one quarter of the time and 5 volts three-quarters of the time[4].

Because this is a hardware function, the pin will generate a steady wave after a call to analog Write in the background until the next call to analog Write (or a call to digital Read or digital Write on the same pin).

Analog pins unlike digital ones, do not need to be first declared as INPUT nor OUTPUT [4].

The following example reads an analog value from an analog input pin, converts the value by dividing by 4, and outputs a PWM signal on a PWM pin:

int led = 10; // LED with 220 resistor on pin 10

int pin = 0; // potentiometer on analog pin 0

int value; // value for reading

```
void setup(){} // no setup needed
void loop()
{
value = analog Read(pin); // sets 'value' equal to 'pin' value /= 4;
                // converts 0-1023 to 0-255
analog Write(led, value); // outputs PWM signal to led
}
```

Chapter 3

Sensors

A sensor as an input device that produces an output (signal) for a given physical quantity (input).

An LDR or a Light Based Resistor are the simplest example of a sensor. It is a device whose resistance varies according to the strength of light to which it is exposed. When there is lighter falling on an LDR, its resistance becomes very small and when the light is smaller, well the LDR resistance becomes very high.

In a voltage divider, we can connect this LDR (along with other resistors) and check the voltage drop through the LDR. It is possible to calibrate this voltage to the volume of light falling on the LDR. Hence A Light Sensor [5].

What are sensors?

Sensors are devices that are used to detect, and often to measure the magnitude of something. They basically operate by converting mechanical, Magnetic, thermal, optical, and chemical variations into electric voltage.

3.1 Classification of Sensors.

There are several classifications of sensors made by different authors and experts. Some are very simple and some are very complex.

They are classified into Active and passive in the first classification of sensors .Those that need an external excitation signal or a power signal are

Active Sensors. On the other hand, passive sensors do not need any external power signal and produce the output response directly.

The other type of classification depends on the detection means used in the sensor. Some of the detection methods include electrical, biological, chemical, radioactive, etc.

Analog and Digital Sensors are the final classifications of sensors. Analog Sensors produce a measured analogue output. Digital Sensors work with discrete or digital data, in contrast to Analog Sensors. Data in digital sensors used for transmission and conversion is digital in nature [5].

3.2. Different Types of Sensors

The following is a list of different types of sensors that are commonly used in various applications. All these sensors are used for measuring one of the physical properties like Temperature, Resistance, Capacitance, and Heat Transfer [5].

Types of sensors

Temperature Sensor, Pressure Sensor, Light Sensor, proximity Sensor etc.

3.2.1 Temperature Sensor

The temperature sensor is one of the most common and most popular sensors. As the name suggests, a temperature sensor senses the temperature, the changes in temperature are measured. Changes in the temperature of a temperature sensor correspond to a change in its physical properties, such as resistance or voltage. Temperature sensors such as temperature sensor ICs (like LM35), thermistors, thermocouples, RTD (resistive temperature devices), etc., are available in various types [5].

How does this sensor work?

It converts the ambient temperature into Variable voltage.

The unit is the measure of temperature

°C =5/9(F-32) (European System).

°F =9/5°C +32 (America System).

They are products that are manufactured in different ways to suit the temperature measurement of different materials.

3.2.1.1 Types of temperature sensors.

1) Thermocouple.

2) RTD. (Resistance temperature detector).

3) Thermistors.

4) IC sensors.

Table 3.1 Types of temperature sensor

Thermocouple	RTD	Thermistors	Semiconductor
Widest Range: -184°C to 2300°C (Low-Voltage output)	Range -200°C to +850 °C (Low cost)	Range 0 °C to 100°C (High sensitivity)	Range -55°C to 150 °C

3.2.1.1.1 Thermocouple

In all cases, the reference cold junction is maintained at 0°C

A thermocouple (TC) is a sensor that measures temperature the thermocouple is by far the most widely used temperature sensor for industrial control. Thermocouple operate on the principle that when two dissimilar metals are joined, a predictable DC voltage will be generated that relates to the difference in temperature between hot junction and the cold junction ,illustrated in fig 3.1.

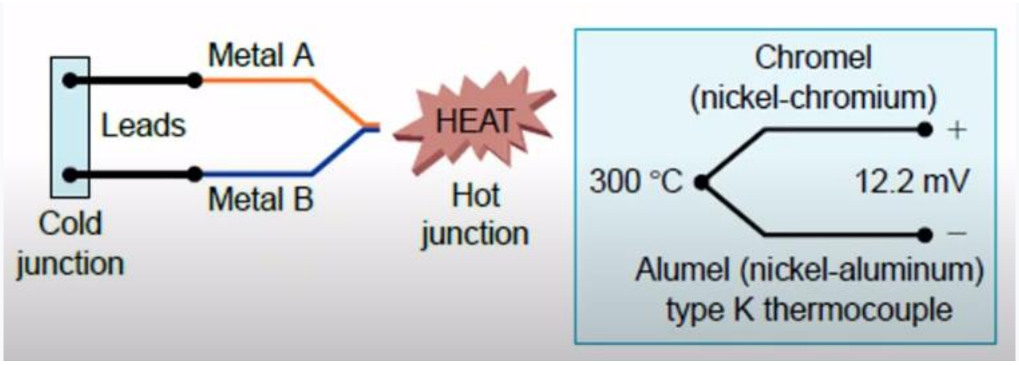


Figure 3.1 Thermocouple heat sensor

Type K (chromel–alumel) is the most common general-purpose thermocouple with a sensitivity of approximately 41 µV/°C.

Equation 1 provides a linear approximation of the Seebeck effect.

$\Delta V = S \times (T_h - T_c)$ (Eq.3.1)

ΔV: Voltage difference between two dissimilar metals

S: Seebeck coefficient in V/K (commonly in µV/°C)

$T_h - T_c$: Temperature difference between hot and cold junctions

3.2.1.1.1.1 Connect Thermocouple with temperature controller.

Fig 3.2 shows, it receives the (mv) signal and takes it on amplifier, d, and its hands ADC, and it transfers it from analog to digital, sends the data to the CPU. This program remedy is present and outputs it to the DAC. It works and stops according to the output that is out of the CPU and at the same time it exits on the display.

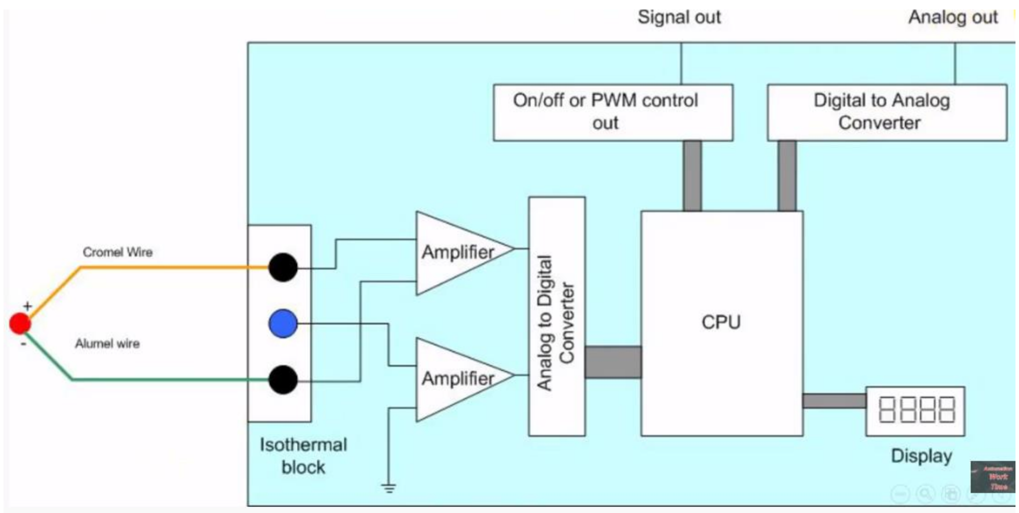


Figure 3.2 Connect Thermocouple with temperature controller.

3.2.1.1.1.2Common types of thermocouple.

To understand thermocouple behavior , it is necessary to consider the non linearities in their response to temperature to temperature differences shows the relationship between sensing junction temperature and voltage output number of thermocouple .

Table 3.1 Some common thermocouple

Junction Materials	Range (°C)	Normal sensitivity(μv/°C)	Ansi designation
Platinum(6%)/Rhodium Platinum(30%)/Rhoduim	38 to 1800	7.7	B
Tungsten (5%) / Rhenium Tungsten (26%) / Rhenium	0 to 2300	16	C
Chromel – constantan	0 to 982	76	E
Copper – constantan	-184 to 400	45	T
Iron - constantan	0 to 760	55	J

Platinum(13%)/Rhodium-Platinum	-184 to 1260	39	K

Design a control system to control temperature of an object or liquid using thermocouple.

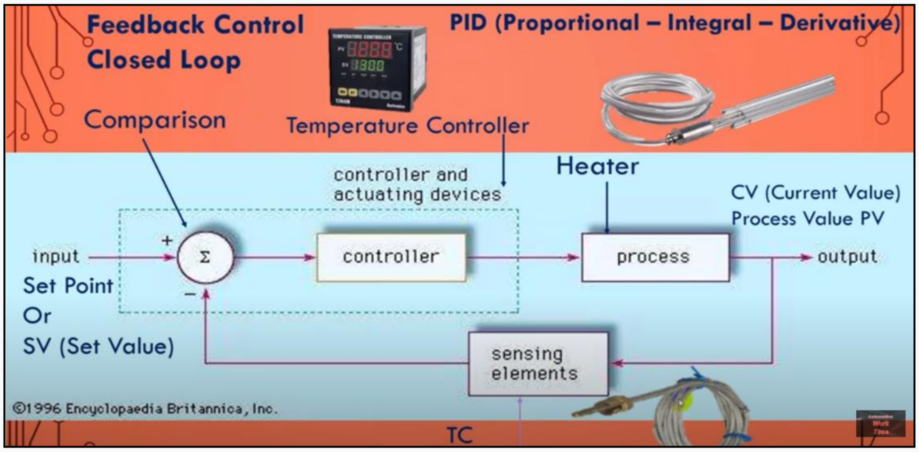


Figure 3.3 Feedback control closed loop.

How does this process work?

Shows fig 3.3, Set the set point, and this is the input for our controller. It takes the set value that you set as 100°C, the sensing element, readers less than 50°C, so the controller looks at the output of the heater, which is the process, so it works on. It starts to heat up and boils down the temperature. Controller again for comparison between set point, and output reading when the input equal output is switched on by the controller, it turns off the heater and turns it off, and when the temperature drops again, it starts to reset again via sensing element.

3.2.1.1.2 IC integrated circuit.

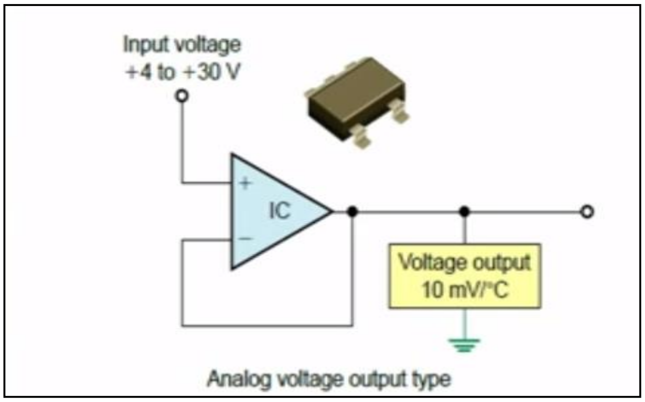


Figure 3.4. IC Temperature sensor

Temperature sensors use a silicon chip for sensing element .Most are quite small and their principle of operation is based on the fact that semiconductor diodes have temperature -sensitive voltage versus current characteristics .Although limited in temperature range (below200°C), IC temperature sensors produce a very linear output over their range ,shows in fig(3.4) .There are two main types of IC temperature sensors analog and digital . Analog sensors can produce a voltage or current proportional to temperature. Digital temperature sensors are similar to analog temperature sensors, but instead of outputting the data in current or voltage, they convert the data into digital format. Digital -output temperature sensors are therefore particularly useful when interfacing to a microcontroller.

3.2.1.1.2.1 Most common type of IC sensor (LM35).

It consist of three terminals, illustrated in fig 3.5.

1) The voltage at which the thermal sensor operates

2) Output.

3) GND

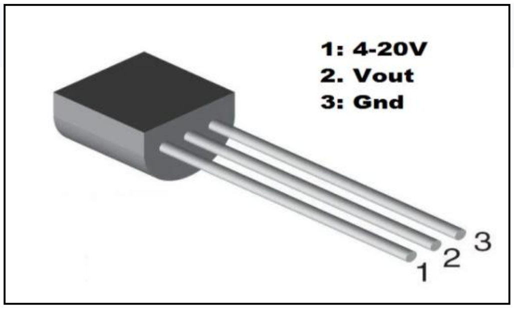


Figure 3.5. LM35Temperature sensor.

The technical specifications of the sensor (LM35)

1) The sensor accuracy is 0.5 °C, which is good for most of our applications.

2) Its recharging effort ranges 4 to 20 V.

3) The temperatures it deals with range from 55 degrees below zero to 150 degrees above zero.

The output voltage of this 3 pin temperature sensor is directly proportional to the ambient temperature and is given by formal:

Vout =K*T (Eq.3.2)

Where,

K=10 mV/°C (sensor constant).

T=Ambient temperature.

3.2.1.1.3 RTD (resistance temperature detector)

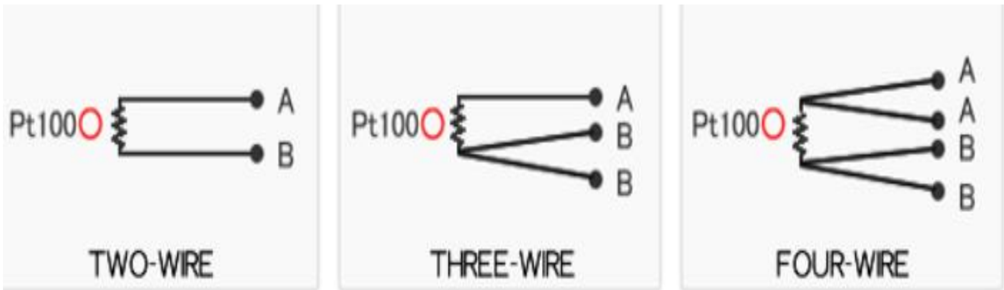


Figure 3.6 Types Resistance temperature detector.

Fig 3.6 shows, Are wire-wound temperature -sensing devices that operate on the principle of positive temperature coefficient (PTC) of metals that means the electrical resistance of metals is directly proportional to temperature. The hotter they become the larger or higher the value of their electrical resistance. Platinum is the material most often used in RTD because of its superiority regarding temperature limit linearity and stability.

EX: 100 ohm PT .

3.2.1.1.3.1 Concept of RTD.

RTD are among the most precise temperature sensors available and are normally found encapsulated in probes for external temperature sensing and measurement or enclosed inside device 's function A controller uses the signal from RTD sensor to monitor the temperature of the liquid in the tank and thereby control heating and cooling lines shows in fig 3.7 .

.

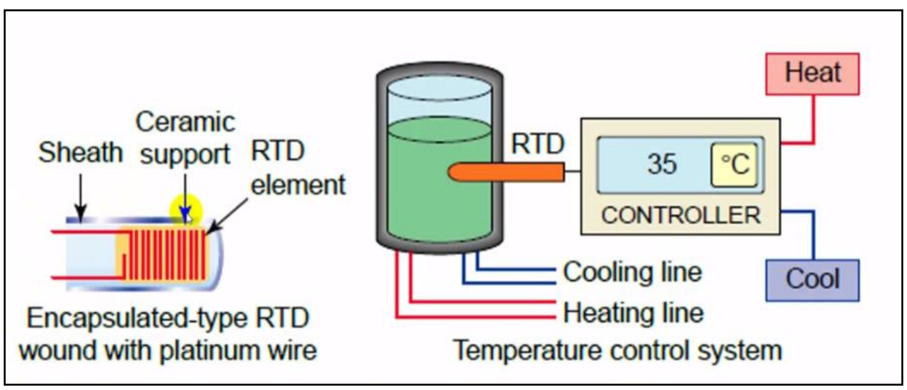


Figure 3.7 Concept Resistance temperature detector.

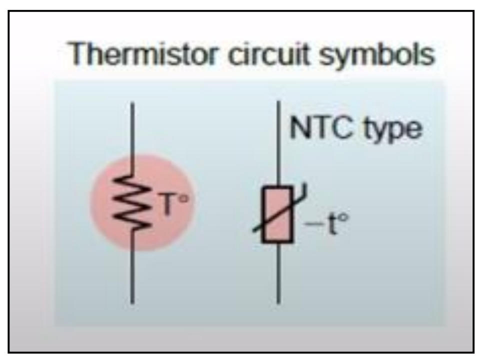
3.2.1.1.4 Thermistors

Thermistors are generally described as thermally sensitive resistors that exhibit changes in resistance with change in temperature .This change of resistance , where the resistance decrease with an increase in (NTC thermistor) when the resistance in temperature , the result is positive temperature coefficient (PTC thermistor.) in fig (3.9) The types of thermistors.

Figure 3.8 Types of thermistors.

Thermistors tend to be more accurate than RTD and thermocouples, but they have a much more limited temperature range. Their sensing area is small, and their low mass allows a fairly fast response time of measurement. A thermistor placed inside a motor housing is used to supplement the standard overload protection by monitoring the motor winding temperature ,shows in fig 3.9 a.

(a)



(b)

Figure 3.9 a) thermistors inside motor, b) Symbol of thermistor.

3.2.2 Ultrasonic sensor (HCSRO4) *(Range: 2 to 400cm)*

Shows fig 3.10**,** an Ultrasonic Sensor is a device of the non-contact form that can be used to measure both an object's distance and velocity. An Ultrasonic

Sensor operates with a frequency higher than the human audible range depending on the properties of the sound waves [5]

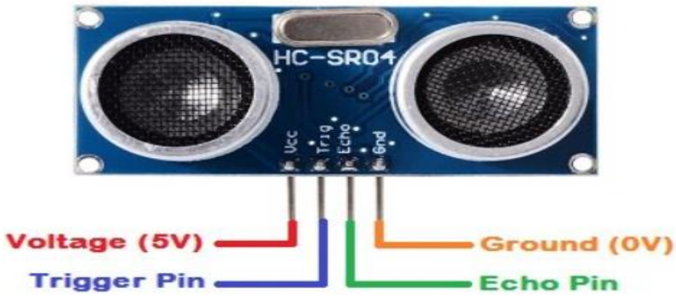


Figure3.10 Ultrasonic Sensor.

3.2.2.1 Working principle Ultrasonic Sensor

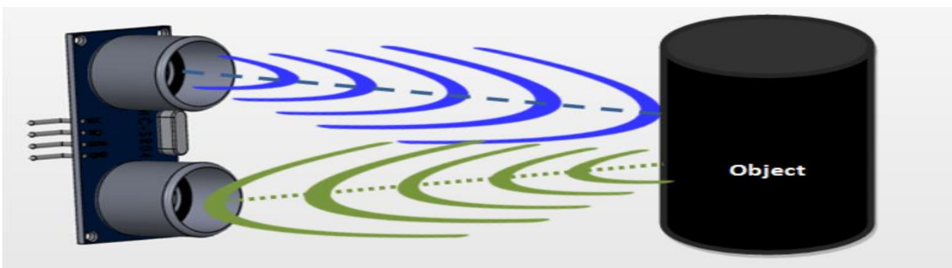


Figure3.11 Ultrasonic Sensor working principle.

Ultrasonic sensor send pulse and object reflect back to the sensor. Time difference between sender and received is used to calculate distance between the objects, shows in fig3.12 [9].

3.2.3 Photoelectric sensor. *Range (10 to 35 mm)*

Shows in fig 3.13, this is a device used by a light transmitter, often infrared, and a photoelectric receiver to detect the distance, absence, or presence of an object. A photoelectric sensor is a device that works by detecting visible or invisible light beam and responding to a change in the intensity of light received. Photoelectric sensors are composed of two basic compoment: transmitter (light source) and a receiver (sensor). These two components may or may not be housed in separate units.

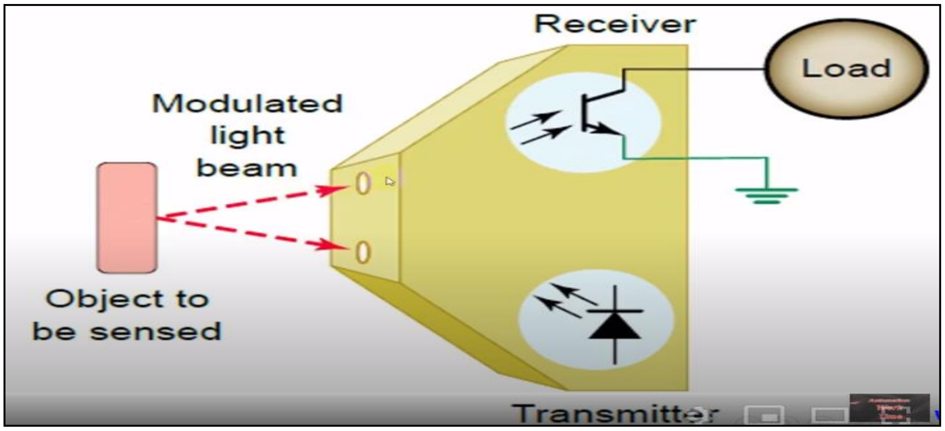


Figure3.12 Photoelectric sensor.

3.2.3.1 The basic operation of photoelectric sensor

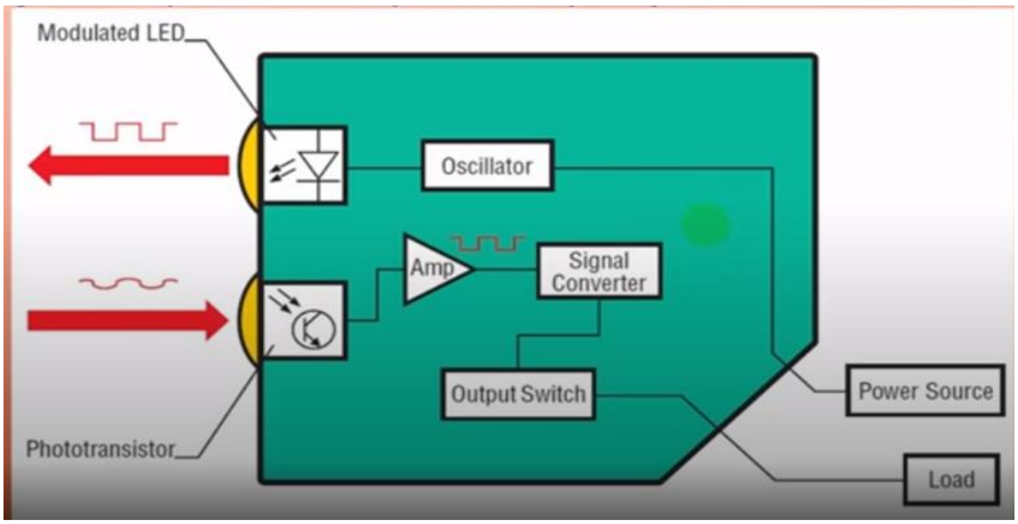


Figure3.13 Operation Photoelectric sensor.

- The transmitter normally contains an LED along with an oscillator from the light source.

- The oscillator modulates the LED at a high rate of speed or turns it off and off.

- The transmitter sends this modulated light beam to the receiver.

- The receiver decodes the light beam and switches to the load-interfacing output device. The receiver is tuned to the modulation frequency of its emitter and only amplifies the light signal that flashes at a given frequency, shows in fig 3.14.

3.2.4 Color sensor.

A color sensor is a type of "photoelectric sensor" that emits light from a transmitter and then detect the light with a receiver that is reflected back from the detector object. The light intensity obtained for red, blue and green will be detected by a color sensor, allowing the color of the target object to be determined [6]. It is consist two parts the first part contain VCC ,GND ,S1,S0 and the second part VCC, GND , S2,S3, output shows in fig 3.15.

Figure3. 14 Color sensor.

Table 3.3 Switches S2 S3

S2	S3	Filter
Low	Low	**Red**
Low	High	**Blue**
High	Low	**No filter**
High	High	**Green**

Table 3.3 Switches S0 S1

S0	S1	
Low	Low	**2%**
Low	High	**20%**
High	Low	**100%**

3.3 Light Dependent Resistor (Light sensor).

Figure3.15 Light sensor.

Is a passive instrument that transforms this "light energy into an electrical signal output, whether visible or in the infra-red areas of the spectrum more generally light sensors are referred to as "photoelectric devices" [5]. **Light Dependent Resistor** (**LDR**) or photoresistor is a special type of light sensor, shows in fig 3.16.

3.3.1 Types of light sensor

3.3.1.1 Photodiode

Definition: A special type of PN junction device that generates current when exposed to light is known as Photodiode. It is also known as photodetector or photosensor and converts light energy into electrical energy [5] shows in fig 3.17.

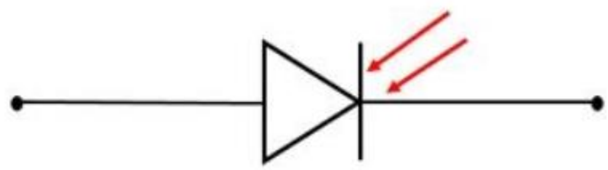


Figure 3.16 Symbol of photodiode

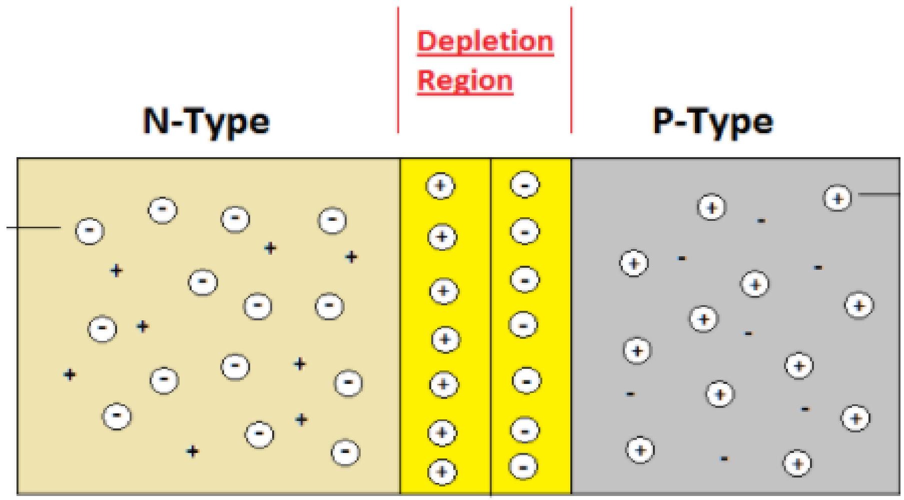


Figure 3.17 working principle of photodiode

Working of photodiode

Photodiodes are a type of light sensor that converts light into an electric current. Basically, when light hits a photodiode, an electron-hole pair is formed. Yet, it's vital to note that the light must have at least 1.1 electron volts for this pair to form. The electrons will have a negative charge, and the hole will have a positive charge. This creates depletion regions in a photodiode shows in fig 3.18. Photodiodes use this electron-hole pair to convert light into an electrical current. Photodiodes are used in various devices, including smoke detectors and televisions [11].

3.3.1.2 Phototransistor

The phototransistor is a semiconductor device that is able to sense light levels and alter the current flowing between emitter and collector according to level of receives light.

The symbol of the phototransistor is similar to that of the ordinary transistor. The only difference is that of the two arrows which show the light incident on the base of the phototransistor shows in fig 3.19.

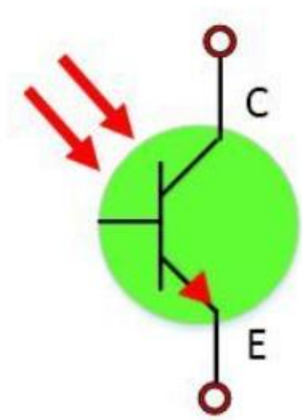


Figure 3.18 Symbol of phototransistor

3.3.1.3 Concept of Light dependent resistors (LDR).

In electronic circuit designs, light-dependent resistors, LDRs or photoresistors are often used where the presence or the level of light needs to be sensed. A number of names from light-dependent photoresistor resistor or even photo cell, photocell or photoconductor can describe these electronic components.

While other electronic components may also be used, such as photodiodes or photo-transistors, in many electronic circuit designs, LDRs or photo-resistors are especially convenient to use. For changes in light intensity, they have significant changes in resistance.

LDRs have been used in a number of different applications in view of their low cost, ease of processing, and their ease of usage. LDRs were used in photographic light meters at one time, and they are still used in a number of applications where light levels need to be detected right today.

What is light dependent resistor, LDR or photoresistor?

An electronic device which is sensitive to light is a photoresistor or light-dependent resistor. Then the resistance changes as light shines on it. The resistance values of the LDR can alter the value of the resistance decreasing over several orders of magnitude as the level of light increases shows in fig 3.17.

It is not unusual for an LDR or photoresistor to have resistance values of many megohms in the dark and then collapse to a few hundred .Ohms in bright light. LDRs are simple to use with such a wide variance in resistance and there are several LDR circuits available. The sensitivity of resistors or photoresistors that rely on light often varies with the incident light's wavelength [8].

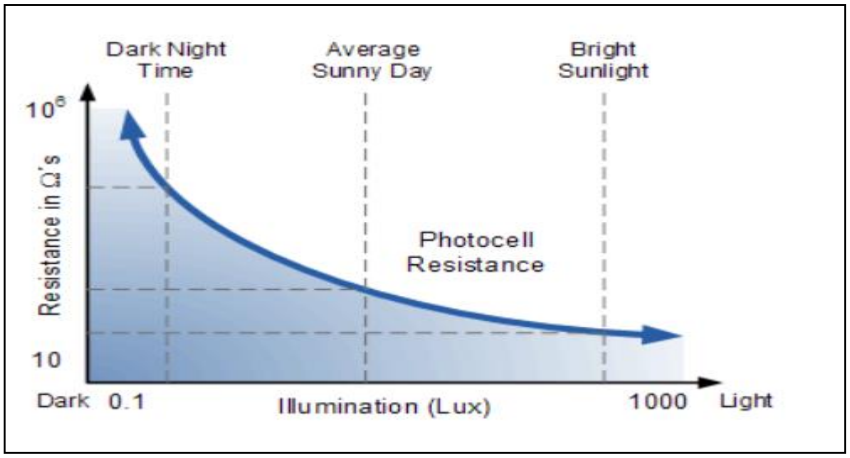


Figure 3.19 Graph between Resistance and Intensity of light.

To allow them to have their light-sensitive properties, LDRs are made from semiconductor materials. Many materials can be used, but cadmium sulphide, CdS, is one popular material for these photoresistors, but the use of these cells is now limited in Europe due to environmental problems with the use of cadmium [8].

What are semiconductors materials?

It is not a conductor substance and not an insulating substance. It works both, but under certain conditions, and it is in nature that it is an insulating substance, the first to which energy is applied in a certain way, it starts to conduct based on the energy value that it is applied to it is this semiconductor, under certain conditions it works as a conductor and in nature it works insulating to benefit in the application that I have, the LDR is a semiconductor, it is an insulating material and thus it is resistant to remain high in the dark places. Just light falls on the surface of LDR and light at the end of it is energy and energy falls on the surface of LDR. The energy stimulates the free electrons in the outer orbit of the atoms. It begins to move and builds up, I have an abstract current. When it happens to have a current, it means that the resistance decreases if there is no current. The meaning of this substance is satisfactory, but its resistance is high.

3.3.2. Positive and negative LDR

Positive LDR when light increase the value of resistance increase so we can say the light intensity is directly proportional to value of resistance while negative LDR when light increase the value of resistance decreases ,the light intensity is inversely proportional to value of resistance .

3.3.3 Types of photoresistor

a) 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 [8].

b) 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 [8].

3.3.4 How it works?

Shows in fig 3.18, the top of the Potential Divider is 5V; the bottom is at 0V and the middle (connected to A0) is some value between 5V and 0V that varies as the LDR resistance varies according to the light level. As both resistors are in series the same current must flow through them both. The LDR resistance drops with light, which causes the current in both resistors to increase (I=V/R), and therefore the voltage across the other (non-LDR) increases. So as the LDR resistance varies with Light, the Voltage at A0 will too.

Where Va0 is the voltage at A0 pin, R2 is the top resistor value, R1 is the bottom resistor value.

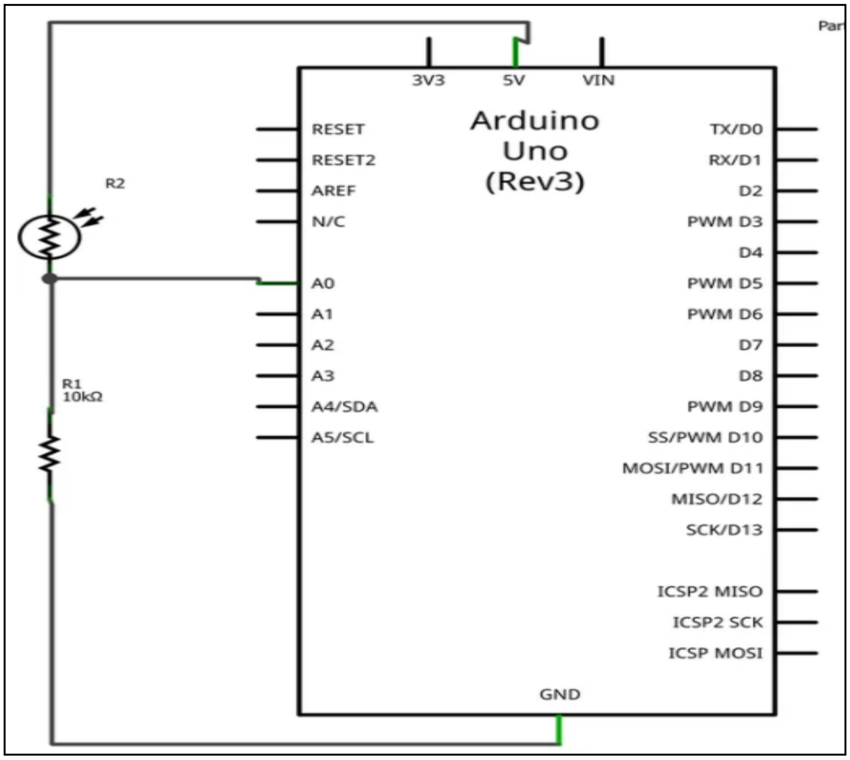


Figure 3.20 Connect LDR Voltage Divider Network.

Example :

R1 = 10k, R2 = 5k

Va0 = 5 * 10000/ (10000 + 5000) = 5 * 10/15 = 3.33V.

The LDR has a high value when no light is present. The value of resistance of the LDR depends on the type. In this case it's about 10k. As the light level increases the resistance drops, which makes the current increase (by Ohm's Law), which in turn, makes the voltage at A0 (Va0) increase [7].

Basis For Comparison	Photodiode	Phototransistor	LDR
Definition	It is a type of PN-junction diode which generates electric current when light or photon is incident on their surface.	It is a type of transistor which converts the light energy into an electrical energy.	light-dependent resistor is a passive component that decreases resistance with respect to receiving luminosity (light) on the component's sensitive surface.
Generates	Current	Current & Voltage	Voltage
Responsivity	faster	Medium	Slow
Coverage area	Very small	Medium	Slow
Range of cost	12 LE	10-15 LE	2-20 LE

Table 3.4 Comparison between types of light sensor

3.3.5 Advantages of LDR

1. Large active area
2. Simpler, they require very small power and voltage for its operation.

3.4 Soil moisture sensor

Soil moisture sensors measure the water content in soil to minimize manual intervention by the farmer and to prevent excessive wastage of water and electricity, when the soil is having water shortage the module output is at high level else the output is at low level

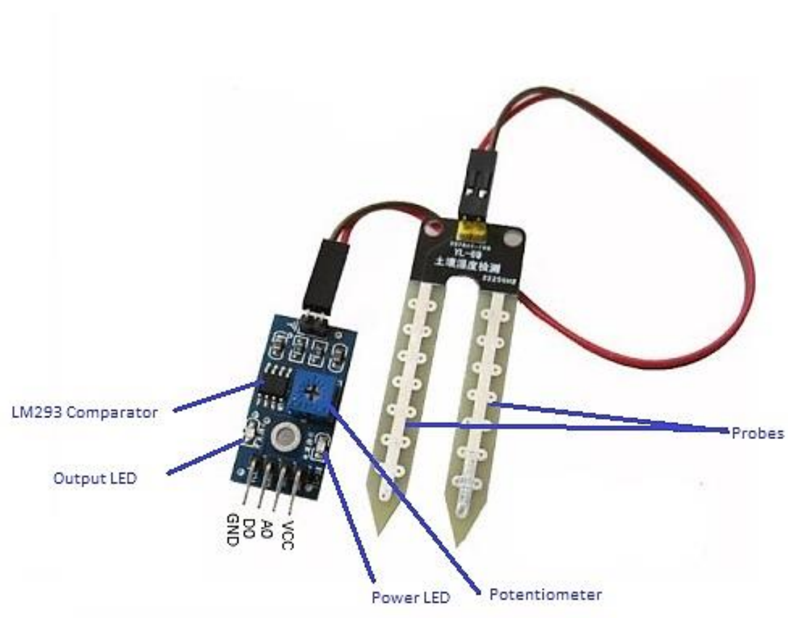


Figure3.21 Soil moisture sensor

The sensor consists of two parts: the electronic board and the probe consisting of two owls as shown in figure3.21, which work to discover water in the soil.

3.4.1 Pin Description of sensor

- Probes : dipped in the soil whose moisture content should be measured
- Potentiometer (10K) : use to vary the sensitivity of the module
- D0 : digital output
- A0 : analog output
- VCC : 3.3V to 5V
- External wire 20 cm : to connect between probes and module as shown in fig 3.21

The sensor output voltage changes according to the change in soil moisture, when:

The soil is moist: the output voltage is reduced

Soil is dry: the output voltage is higher

3.4.2 working

Working Soil moisture sensors measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. Soil moisture content may be determined via its effect on dielectric constant by measuring the capacitance between two electrodes implanted in the soil. Whose resistance varies according to the water content in the soil and soil temperature. Therefore, careful calibration is required and long- term stability of the calibration is questionable. In this sensor -we are using 2 Probes to be dipped into the Soil

Figure3.22 Soil moisture sensor

This resistance is inversely proportional to the soil moisture

- The more water in the soil means better conductivity and will result in a lower resistance.

- The less water in the soil means poor conductivity and will result in a higher resistance.

The sensor produces an output voltage according to the resistance, which by measuring we can determine the moisture level.

3.4.3 Advantages of moisture sensor

1. This makes increase in productivity
2. Reduces man power
3. Much land will be irrigated
4. System can be switched into manual mode whenever required

3.5 Water level sensor

A water level sensor is a system that relays information back to a control panel to indicate whether a body of water has a high or low water level, which is obtained by a series of parallel wires exposed to measure the size of the water droplets quantity in order to determine the water level as shown as figure3.23. There are different ways to measure the liquid level. Some sensors calculate the depth of liquid according to the pressure caused by the liquid's specific gravity and the vertical distance to the surface. Some others emit ultrasonic waves from a transducer which also detects and measures the reflected waves to calculate the liquid depth.

The purpose is to gauge and manage water levels in a water tank. The control panel can also be programmed to automatically turn on a water pump once levels get too low and refill the water back to the adequate level.

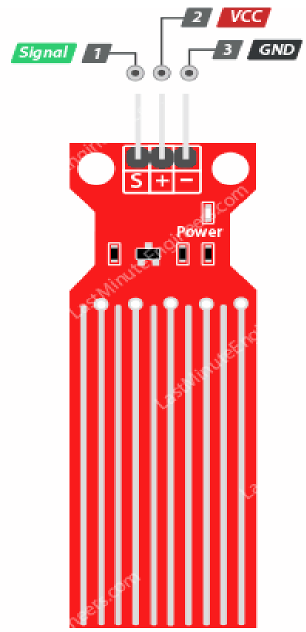


Figure3.23 water level sensor

<u>The water level sensor has 3 pins:</u>

Signal (S): pin is an analog output

VCC (+): pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V – 5V

GND (-): is a ground connection.

3.5.1 working of water level sensor

Water level indicators work by using sensor probes to indicate water levels in a storage tank. These probes send information back to the control panel to trigger an alarm or indicator, the control panel can be programmed to automatically turn on your pump to refill the water again.

- The water level is full – Nothing happens
- Water level drops to the reference probe – Alarm is triggered Fill start is triggered automatically turning on the water to fill the tank Once the

water is full, fill stop is triggered and the system automatically stops the pump

The system resets and waits for water levels to drop again

3.5.2 Benefits of Water Level Indicators and disadvantages

- Easy to install
- Very little maintenance and Automatic save you can save manual labor time
- Automatic water level indicators ensure no overflows or running of dry pumps
- Can help avoid seepage of walls and roofs due to tanks overflowing
- Saves money by using less water and electricity
- Consumes very little energy, perfect for continuous operation

Water level sensor disadvantages include:

- Water level controls need to be replaced every 3 years due to The rust
- Electronics are usually built separately

Water level indicators are important for many different industries can be used in Hotels, Pools, Factories, fire protection systems in buildings and more. . For example, cooling towers use water level indicators to monitor water levels in a tank and make corrective actions based on the level of water. Without water level indicators in a water tank, you would have to manually check whether enough water is in the tank, and should your tank ever go empty, it could mean your chiller overheating. Water level indicators allow you to remotely monitor water levels and make corrective actions automatically so you can focus on more important issues.

Chapter 4

Renewable sources

Renewable sources are energy sources whose natural renewal is so fast, that do not have a finite limit, or those that can be recycled [13]. There are several types of renewable energy, usually from natural sources. Sun, for example, can never be depleted this energy in our lives, renewable energy comes in many ways, and its use increases year after year, It's not about that, the cost of renewable energy is starting to fall, making it more possible now than ever [14]. It is expected that it will account for about 20 percent in 2022 and 42 percent in 2035 from electricity generation.

4.1 A History of Renewable Energy

The electricity we used for lighting and heating was from renewable sources until the discovery of coal deposits. And the coal that powered the industrial revolution in the Western world was found, and then learned to tap oil that contributed to the acceleration of the inventions that would lead to the 20th century, we burned the "bio mass" through much of human history: planet material such as trees, grass, mosses, to heat our hearths and later, homesteads. When the hearth and fireplace became central to households, it became an essential fuel source. The invention of fire is a history of humanity and a history of renewable energy use. Before the discovery of oil in antiquity and widespread oil drilling during the modern period, society was in that fashion. Other applications in ancient times include animal strength and wind for the sail that for 8,000 years of human history has powered commerce. It is not a novel concept to build dams to get strength from the fluid motion of water. In the 1970s, we looked out to the ancient techniques and technology used to supply tomorrow's electricity supplies. In the 1870s, peak oil and peak carbon were theorized. Thinkers developed notions of solar energy back during the industrial revolution to brace for a post-coal environment. Early in the process of mass mining of coal and oil, we learned that It would be a high, and it was time to run out. Solar energy investment lasted until the outbreak of WWI. A paper in Scientific American hypothesized in 1912 that fossil reserves would run out and our only alternative was solar power. We started a fresh drive for renewables in the 1950s. As environmentalists and industrialists, solar and hydro were caught. We noticed that it is a scarce resource and now, regardless of the availability, it would run out. Movement in the environment, The growth of environmental technology and the movement against emissions have meant that green energy is a reality and not just a technological innovation for the future. So, now we know what we got from the height of crude. Experts believe that in 2008 this happened. Shockingly, since1986, demand has outstripped supply, prompting economists, science experts, and environmental activists that what is on the land remains on the ground. Since the 1990s, turmoil in oil-producing countries has led to volatility and taken the question of global energy security to the fore [15] .

4.2 Top five examples of renewable resources:

4.2.1 Wind energy:

You need big enough land and strong winds in your area to take advantage of it. When you live on a farm and produce enough wind energy that can be rented to energy providers, the purpose is to use the mechanical energy that comes from the movement the winds to windmills and putting them into a generator and producing electricity. They have been exploited since ancient times as boats were used Sailboats and windmills [16].

Wind turbines are an ideal way to use renewable technology, but it does need to be well thought out. The biggest environmental disadvantage is that it would harm animal migration at sea [16].

Figure4.1: wind energy

4.2.2 Hydroelectric Power

Hydroelectric, as a renewable energy resource, is one of the most commercially developed. A large reservoir may be used by constructing a dam or barrier to create a controlled flow of water that will drive a turbine, producing electricity. This energy source can also be more reliable than solar or wind power, it also enables electricity to be stored for use, Construction of hydropower plants has been known to displace local communities, impede migration habits of fish population, hydroelectric is a perfect source of energy when achieved in an environmentally-friendly, well controlled manner. Water will still flood and is entirely sustainable until there is a drought [16].

Figure4.2: hydroelectric energy

4.2.3 Geothermal energy

Geothermal power operates by using geothermal heat pumps to produce energy using the heat from the earth's center. In regions with volcanic activity, such as Iceland or the west coast of the US, geothermal energy can be found more effectively, since there is a lot of underground movement in these areas and the heat of the earth is working its way to the surface. Examples of this can be seen by geysers firing steam into the air on the surface of the earth, using radiation to produce geothermal energy. The expense-it is not yet able to cope with cheaper energy sources such as solar or wind-is one drawback to geothermal. Creating geothermal plants and drilling deep enough to get to the hottest region of the world is very costly. The downside of not being able to compete with cheaper energy sources, such as solar or wind, is one limitation of geothermal energy [16].

4.2.4 Biomass Energy

This is the conversion of solid fuels made from plant material and organic animal waste into electricity. While biomass primarily includes burning organic materials to generate electricity, this is a much cleaner and more energy-efficient process today. By converting agricultural, industrial and household waste into solid fuels, liquid and gas, at a much lower economic and environmental cost, the biomass generates electricity [16].

4.2.5 Solar energy:

Sunlight is one of the most much and available energy on our planet freely. The sum of solar energy reaching the surface of the earth in one hour is more than the total energy needs of the world for a whole year. Although it sounds like a great source of renewable energy, the amount of solar energy we can use varies according to the time of day, the season and the geographical location of the year [20].

Figure4.3: solar energy

Panels can produce electricity for several years. When solar panels are produced and built, all they do is sit there and generate electricity, providing pollution-free energy over their lifespan following the production of renewable resources such as solar panels [20].

4.3 Comparison between solar and other renewable sources

4.3.1 Solar VS Hydro

hydroelectricity is typically supplied by the use of large dams, which also means that the initial cost of installation would be very high. Building a dam has the potential to change an entire ecosystem as well. The natural flow of the rivers they take over is also modified by hydro plants, creating new dams and decreasing water flow downstream. These facilities can prevent fish migration and change ecosystems [17].

On the other hand, photovoltaic panels in contrast to dams, are thin, Solar don't modify the environment and can built in a few months as compared to hydro and Land or rooftop solar installation can be setup almost anywhere sunshine as compared to hydro as shown in figure4.4 [17].

Figure4.4: hydroelectric VS solar energy

4.3.2 Solar VS Wind

Although wind power has been on the market for a long time. Generating primary energy collected from wind is less expensive, and wind turbines require much more maintenance than photovoltaics. Wind generating stations are often set up in remote areas [17].

Building mills are far from where I need this energy, and it is possible during transport to lose electricity in transmission lines, unlike solar energy that is close to the place and possible on the roof of homes [17].

Figure4.5: wind VS solar energy

4.3.3 Solar VS Biomass

Burning biomass to produce electricity has some attraction. Unfortunately, biomass produces organic compounds such as carbon monoxide and nitrogen oxides that are volatile. On the positive hand, in contrast to conventional fuels, its emission is modest. In that they produce no pollution and do not need land that could be used for crops, photovoltaic cells again prove superior [17].

Furthermore, solar panels have efficiencies of as much as 22.5%, which ensures that much of the energy of the sun is converted into electricity. Biomass performance is much, much smaller, maybe less than 1% [17].

Photovoltaic cells are superior compared to biomass as they don't occupy fertile land that could be used for crops [17].

4.4 What is a Solar Cell?

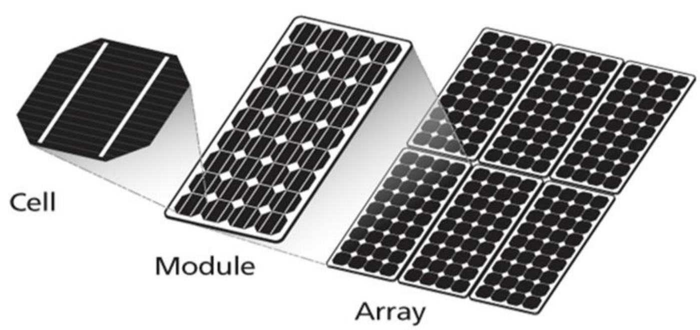


Figure4.6: solar cell to solar array

A solar cell also known as a photovoltaic (PV) cell is a smallest and basic building block of a PV system (solar module and a solar panel), Basically is a sandwich composed of two semi-conducting material slices, typically silicon, it's an electrical device that, by means of a photovoltaic effect, transforms light energy directly into electricity, It is a type of photovoltaic cell, defined as a device whose electrical characteristics, such as current, voltage or resistance, differ when exposed to light [23].

Regardless of whether the source is sunlight or artificial light, solar cells are defined as being photovoltaic in addition to generating electricity [23].

4.4.1 Working and construction of solar cell

For the making of PV cells, semiconductor materials such as arsenide, indium, cadmium, silicon, selenium and gallium are used. The cell uses both silicon and selenium. The solar cell consists of a semiconductor (emitter) layer of type n and a semiconductor layer of type p (base). The two layers are sandwiched and then the p-n junction is formed, the surface is coated with anti-refection coating to prevent the loss of incident light energy due to reflection [18].

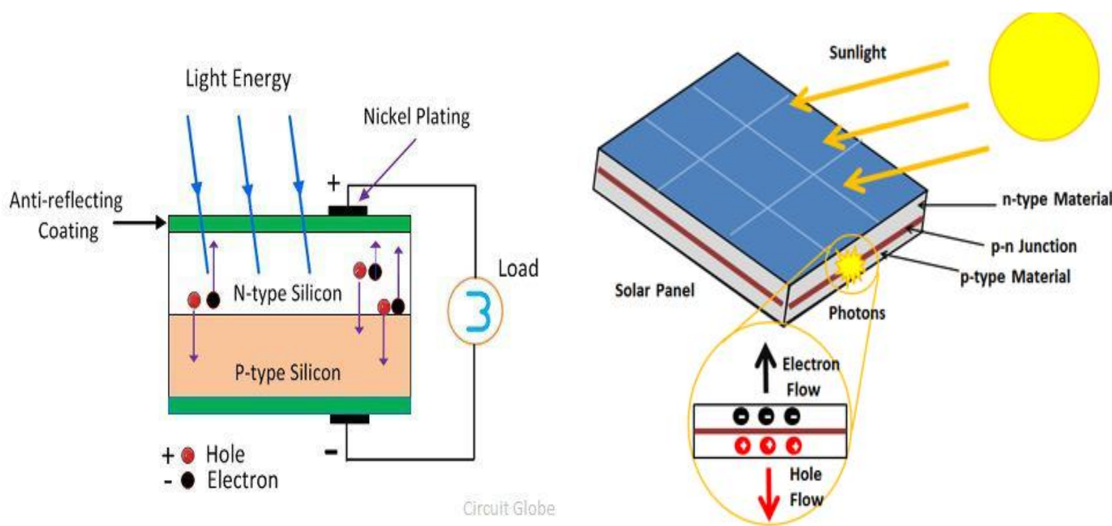


Figure4.7: construction of solar cell

1. By increasing the potential energy between the P-Type and N-Type semiconductors. There is a difference in electrical charge between the top of the semiconductor of the P-Type and the bottom of the activating electron motion of the N-Type semiconductor.

2 The N-Type semiconductor has additional electrons and when photons reach the P-N junction, they travel up to the P-N.

3 There are "holes" or electron "voids" in the P-Type semiconductor and they hold the extra electrons from the N-Type semiconductor.

4 Electrons flow from the semiconductor of the P-Type to the electric load. As the electron carriers are emptied, the "voids" return to the semiconductor bottom of the P-Type and await a free electron.

5 Electrons flow through the conductor from the electrical load and head into the N-Type semiconductor and the process begins again.

4.5 Solar module

Also called solar panels, a solar module is a single photovoltaic panel that is solar panels have several smaller units called photovoltaic cells (Photovoltaic literally means that they turn sunlight into electricity.) A solar panel is made up of several cells connected together [7].

The solar cells absorb sunlight as a source of energy to generate electricity. An array of modules are used to supply power to buildings [19].

Figure4.8: solar panels

4.6 Types of solar panels:

1. Mono crystalline panel

They are created using cells cut into strips from a cylindrical crystal of silicon. It is the most beautiful of them because of the gaps between the chips as shown in figure4.7. This is the most effective and efficient photovoltaic technology, which usually converts about 22.5% of the sun's energy into electricity and its lifetime is 25 years or more. The production process required to manufacture monocrystalline silicon is complex, resulting in slightly higher costs than other technologies [21].

$$\eta_{O-E} = \frac{P_{electrical}}{P_{optimum}}$$

Figure4.9: mono crystalline panel

Table 4.1: Advantages and disadvantages of mono crystalline panel

Advantages	Disadvantages
Highest efficiency and performance	Most expensive
High lifetime value	A significant amount of silicon is wasted

2. Poly crystalline panel

Polycrystalline silicon cells are also sometimes referred to as polycrystalline cells, and they are made of cells cut from an alloy of melted silicon and poured into molds depending on the shape to be used. They are usually cheaper to produce than monocrystalline cells, due to the simpler manufacturing process, but they tend to be slightly less efficient, polycrystalline panels are less successful than monocrystalline panels and their efficiency is only 16.9% and Its lifetime is 25 years or more [21].

Figure4.10: polycrystalline panel

Table 4.2: Advantages and disadvantages of poly crystalline panel

Advantages	Disadvantages
Low cost	Low efficiency and performance
Less silicon is wasted during manufacturing	Lower heat tolerance
The manufacturing process is faster	

3. Thin film panels

It is the most flexible type, takes the shape of the surface on which it is installed, and is less efficient (no more than 12%) and low in cost due to the relatively easy manufacturing method: silicon is deposited onto glass or plastic, and the lifetime does not exceed 15 years [21].

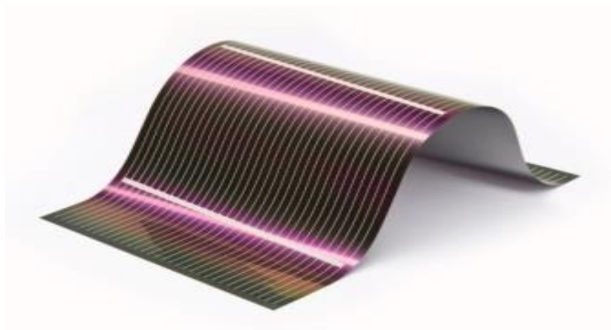


Figure4.11: Thin film panel

Table 4.3: Advantages and disadvantages of thin film panel

Advantages	Disadvantages
Low cost	Lowest efficiency and performance
More flexible	Shorten lifetime
	Requires more space

- **3 Important Factors in Choosing Solar PV**

1 Assess the performance of solar panels and compare the industry average of 16-18%

2 Test the manufacturer's solar panel warranties against an industry average of 10-25 years

3 Performance is important in comparing cost to relative efficiency, but the most effective panels are not necessarily the best value.

4.7 Mini Solar Panel 22V/0.24A – 5.2Watt

Figure4.12: mini monocrystalline panel

- It was used in the project with Specifications:
  - CELL TYPE: Mono Crystalline
  - Rating: 22Vdc/0.2A
  - Can be used for batteries charging during outdoor trip, camping, hunting or fishing trip
  - Ideal for small home projects, science projects, electronic applications and charging small DC batteries
  - Size: 210mm x 165mm
  - WEIGHT: 100g
  - OPERATING TEMP: -20 ~ +60 C

4.8 Advantages of Solar Energy

1. Solar energy is cheap, it comes directly from the sun and does not produce any emission, so it is used in rural areas where it is difficult to obtain electricity mainly

2. Solar energy, because it will last forever, will hold up more than the energy reserves in the world.

3. Is a renewable energy source that generates energy as long as the sun shines.

4. Generate electricity from the sun without noise.

5. For cells and solar panels, there is very little maintenance required and they last for a very long time and are easy to install

6. Once the panels or solar cells are installed, the electricity cost will be reduced. Only in cloudy conditions will electricity be needed from power facilities.

4.9 Disadvantages of Solar Power

1 The only time solar energy can be consumed and transformed is during the afternoon and when the sun is shining.

2 The panels and cells which are used to absorb the sunlight are expensive to purchase.

3 Solar power plants are unable to allocate adequate electricity to serve vast regions. They are not able to compete with the big conventional power stations.

4 Solar power plants require vast quantities of land for the panels and cells to absorb enough sunlight to generate enough energy.

The quality of solar cells will have to go up in order for solar power to make more gains.

4.10 Solar Energy Technologies:

Solar energy technologies use the sun's energy and illumination to supply residences, industries and industry with heat, light, hot water and electricity.

1) Solar Hot Water — Heating water with solar energy.
2) Photovoltaic Systems — Producing electricity directly from sunlight.

4.10.1 Solar hot water

Solar hot water shown in figure 4.13 is an alternative to traditional water heating systems, including tank less coil water heaters, gas water heaters, electric water heaters, or heat pump water heaters (all using either gas, oil, or electricity to power them). For decades, but not until the 1980s, did solar hot water companies begin to take off in the U.S., making solar hot water a viable option for property owners we have used solar energy to heat water [26].

How a solar water heating system works: the basics

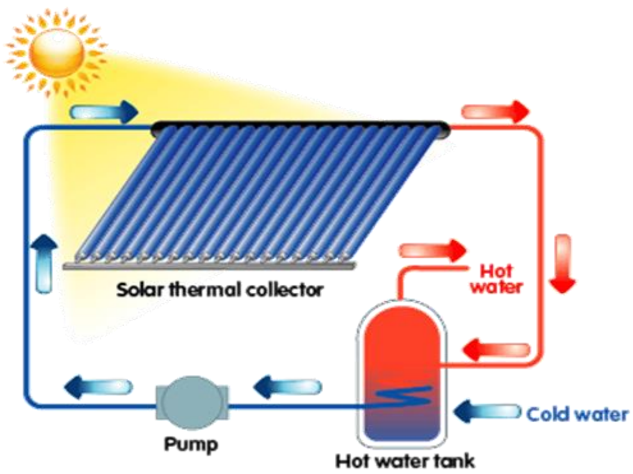


Figure4.13: Solar hot water system

Solar hot water systems capture thermal energy from the sun and use it to heat water for your home. These systems are made of a few major components: collectors, a storage tank, a heat exchanger, a controller system, and a backup heater.

Collectors:

Figure4.14: Collector

The panels are known as' collectors' in a solar thermal system, and are usually mounted on a rooftop. These collectors vary from the photovoltaic solar panels that you are probably familiar with, because they produce heat instead of generating electricity. Sunshine (or 'solar radiation') passes through the glass covering of a collector and hits a portion called an absorber layer, It has a coating optimized for the capture and heat transfer of solar energy. This produced heat is transferred to a 'transfer fluid' contained in small pipes in the plate (either antifreeze or potable water). Collectors come in sizes that vary. Depending about how much sunlight your roof receives and how much hot water you use in your house, the size and amount of collectors you can install. In two types, they are also made: flat plate and evacuated tube. In general, flat plate collectors are less costly, but can absorb less sunlight and are less effective in colder conditions. On your roof, evacuated tube collectors take up less room, but are heavier and more delicate [26].

Heat exchanger and storage tank:

When your collectors heat up the transfer fluid, it travels through a series of pipes known as a "heat exchanger," which is located within your hot water storage tank. The heat is transferred from the pipes to your water when these pipes are filled with heated transfer fluid, allowing hot water that is ready to be used in your home [14].

Co**ntroller system:**

Many solar hot water systems have a control system that ensures that the water doesn't get too hot in the storage tank**.** Controller systems can also stop cycling cold water through the system when it is very cold outside and the transfer fluid is not properly heated [26].

Backup heater:

Lastly, a backup system comes with every solar hot water system. Your backup heater will kick in and produce hot water for your home with gas or electricity on days when it's too cloudy to generate sufficiently warm water from solar energy. Throughout the year, backup heaters will account for about 20 percent of your hot water consumption [26].

4.10.1.1 Types of solar hot water systems: direct vs. indirect and active vs. passive.

Every solar hot water system is made up of the same basic parts, but there are some differences in system design. You have to choose between a direct or indirect system, which impacts how fluid that is heated in the collectors. You also have to decide whether you want an active or passive solar hot water system, which impacts the way that fluid moves through your system.

1. Direct vs. indirect solar hot water.

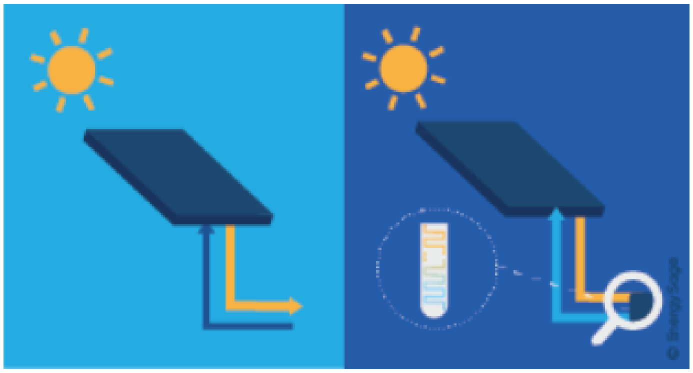


Figure 4.15:Direct vs. indirect solar hot water.

The type of fluid used to absorb heat in the device is the key difference between direct and indirect solar hot water. Solar energy is gathered in an indirect method and held in a special antifreeze fluid. In your hot water storage tank, which heats water for use in your home, the antifreeze is circulated. By contrast, the water gets heat directly from the sun in a direct setup, Rather than being stored first in a transfer fluid, the water gets heat directly from the sun show in fig 4.15.

Indirect solar hot water systems are used for most solar hot water installations in the United States. Indirect systems are more resistant to cold temperatures and, during the colder winter months, are better at storing heat energy. Indirect systems are also, however, more costly than direct systems

Direct solar hot water systems may work for some homeowners in the most southern parts of the country, but most U.S. residents will want to install an indirect system to avoid efficiency losses during colder parts of the year [15].

4.11.2.2 Active vs. passive solar hot water

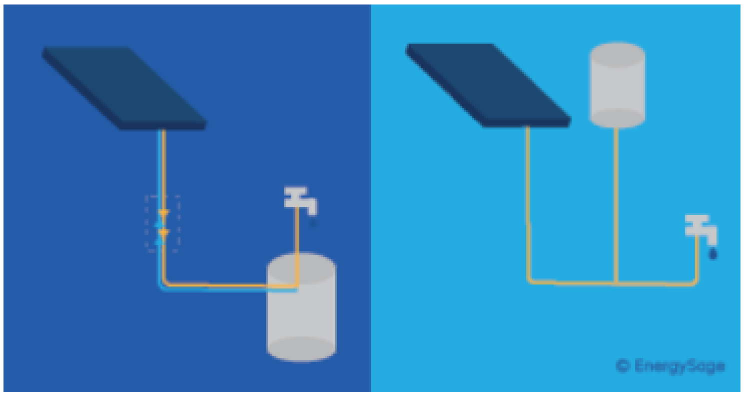


Figure 4.16: Active vs. passive solar hot water

With a control pump or with gravity, antifreeze fluid or water is transferred around the system in your solar hot water installation. Controller pumps are used only in solar hot water installations that are operational. To transfer fluid and water around, passive schemes rely on gravity.

Although it is less difficult to build passive systems, they are also much less effective than active systems. In addition, some passive systems need to mount their storage tank higher than the collectors to run, which can place high levels of stress on your roof. Most solar hot water systems in the U.S. are active, meaning that they have a controller that pumps water or antifreeze fluid through the system.

4.10.2 Photovoltaic systems

A photovoltaic (PV) system consists of one or more solar panels coupled with an inverter and other electrical and mechanical devices to produce power using energy from the Sun. From small rooftop or portable systems to large utility-scale generating plants, PV systems can vary greatly in capacity.

How do these systems work?

A photovoltaic (PV) system consists of one or more solar panels coupled with an inverter and other electrical and mechanical devices to produce power using energy from the Sun. From small rooftop or portable systems to large utility-scale generating plants, PV systems can vary greatly in capacity. While PV systems can act as off-grid PV systems of their own, this article focuses on systems linked to the grid or grid-linked PV systems.

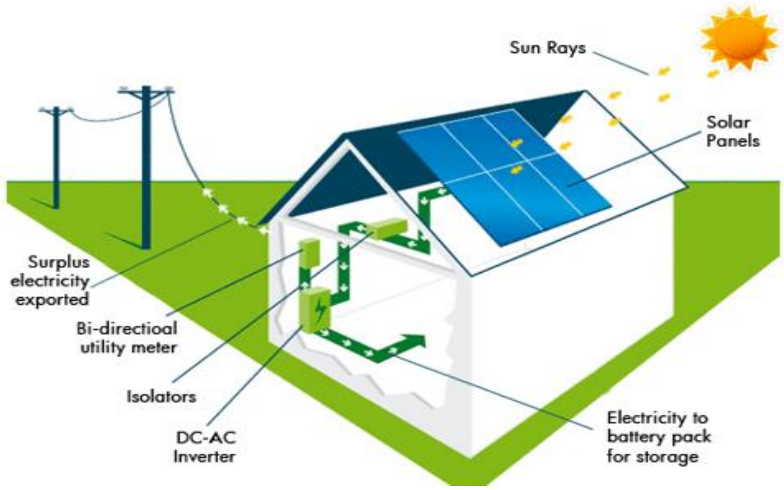


Figure4.17: PV system

The light from the Sun, made up of energy packets called photons, falls onto a solar panel and, through a mechanism called the photovoltaic effect, produces an electric current. Each panel generates a comparatively small amount of energy, but as a solar array, it can be joined together with other panels to generate higher amounts of energy. In the form of direct current, the electricity generated from a solar panel (or array) is (DC) While many electronic devices, including your phone or laptop , use DC electricity, They are planned to operate using a power grid that provides (and requires) alternating current. Therefore, in order for solar power to be usable, an inverter must first be used to transform it from DC to AC. This AC power from the inverter can either be used locally to power electronics, or sent elsewhere to the electricity grid for use. Showing in **fig 4.17**[25].

4.10.3 Smart farm

This approach is often cost-effective compared to traditional methods of providing electricity especially to a remote location where they have trouble constructing power transmission lines, they have no moving parts and are easier to maintain than diesel fuel.

Solar energy can be used in agriculture for a wide range of applications, the most important of which are irrigation, cooling of agricultural products, and grain milling.[36]

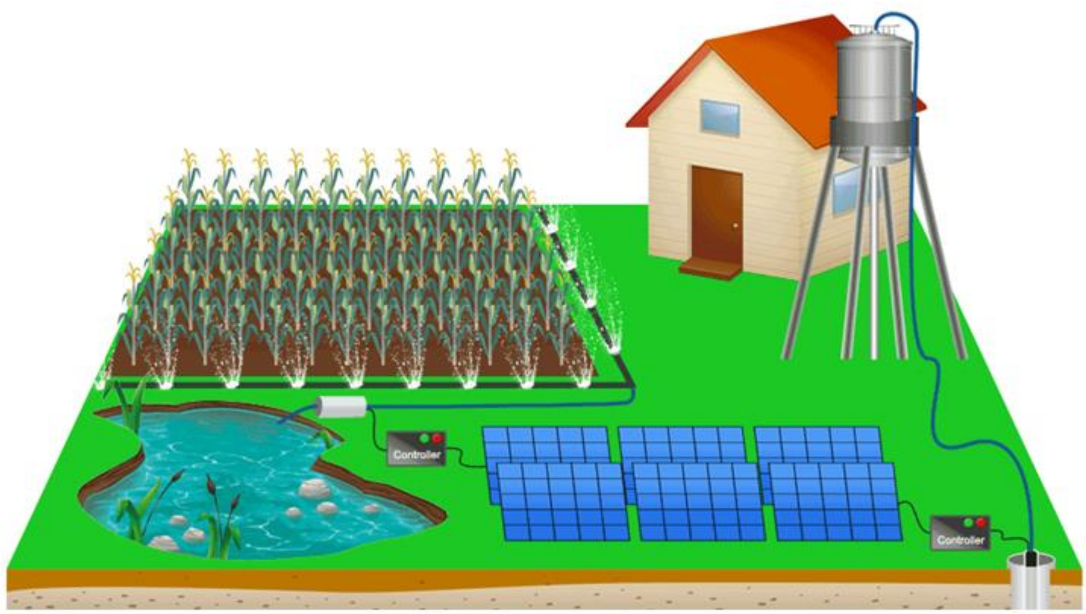


Figure4.18: smart farm system

- **Benefits of smart farming**

By making farming more connected and intelligent, precision agriculture helps reduce overall costs and improve the quality and quantity of products, the sustainability of agriculture and the experience for the consumer. Increasing control over production leads to better cost management and waste reduction. The ability to trace anomalies in crop growth or livestock health, for instance, helps eliminate the risk of losing yields. Additionally, automation boosts efficiency. With smart devices, multiple processes can be activated at the same time, and automated services enhance product quality and volume by better controlling production processes.

Smart farming systems also enable careful management of the demand forecast and delivery of goods to market just in time to reduce waste.[37]

Using solar energy to dry crops and grains

A large proportion of agricultural products spoil during conventional drying in the open air. Using the solar drying method can dry crops faster and at an even rate than leaving them open in the field with the added benefit of protection from birds, insects and worms.

Easily perishable crops are often difficult to dry, and most end up spoiling. With solar drying, you can easily dry these crops and enable longer storage times and easier transportation. This will significantly reduce the number of rotten crops and contribute to increased farmers' income.

Usually a solar dryer consists of a shed, a drying rack and a solar collector, the shed throws out the solar heat coming from the south-facing window and the natural convection or solar fan drives the heat.

If your farm already has a crop dryer it makes sense to replace the conventional fuel that runs the machine with solar energy, you will be able to save fuel and money this way.[39]

Chapter 5

Motors

The electric motor shown in figure 5.1 is an electrical machine that converts electrical energy into mechanical energy. The other way round would be the conversion of mechanical energy into electrical energy and by an electrical generator. Most electric motors operate in normal motor mode through interaction between the magnetic field of the electric motor and the winding currents[27].

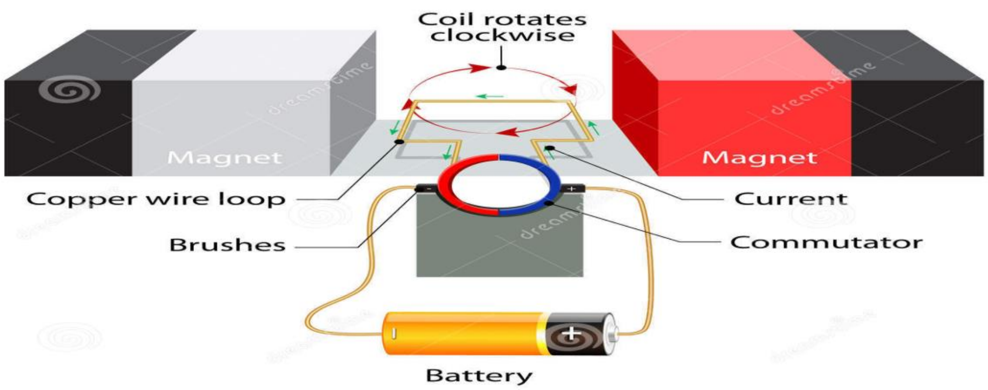


Figure 5.1: A motor diagram

5.1 Construction of electric motor

The electric motor construction can be done using the rotor, stator ,windings, commutator .As shown in figure 5.2

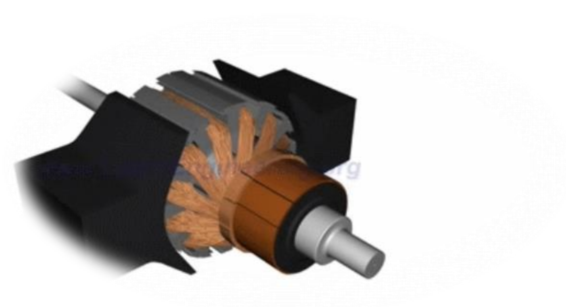


Figure 5.2: Electric motor construction

5.1.1 Rotor

The rotor shown in figure 5.3 in an electric motor is the moving part, and the main function of this is to rotate the shaft for generating the mechanical power. Generally, the rotor includes conductors which are laid to carry currents, and communicate with the magnetic field in the stator [35]**.**

Figure 5.3: Rotor

5.1.2 Stator

The stator shown in figure 5.4 in the motor is the inactive part of the electromagnetic circuit. It includes permanent magnets or windings. The stator can be built with different thin metal sheets which are known as laminations. These are mainly used for reducing energy losses [35].

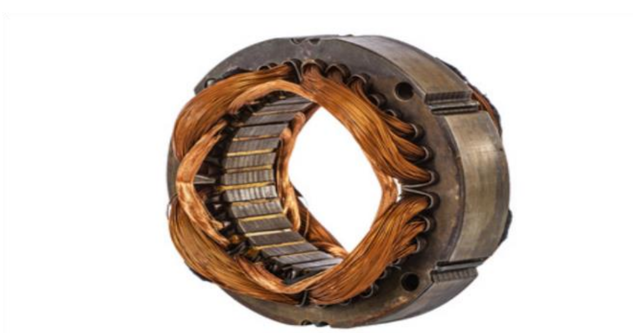


Figure 5.4: Stator

5.1.3 Windings

Windings shown in figure 5.5 in the motors are wires that are laid inside of the coils, generally covered around a flexible iron magnetic core so as to make magnetic poles while energized with the current. For motor windings, copper is the most frequently used material. Copper is the most common material for windings and aluminum is also used although that should be solid to carry a similar electrical load securely [35].

Figure 5.5: Windings

5.1.4 Commutator

The commutator shown in figure 5.6 is a half ring in the motor which is fabricated with copper. The main function of this is to link the brushes toward the coil. The commutator rings are used to ensure the flow of current direction within the coil reverses each half time thus the one surface of the coil is frequently pushed upwards & the other surface of the coil is pushed downwards [35].

Figure 5.6: Commutator

5.2 Electric motor working rule

When current flows through a conducting wire, and an external magnetic field is applied across that flow as shown in figure 5.7, the conducting wire experiences a force perpendicular both to that field and to the direction of the current flow (i.e they are mutually perpendicular) [35].

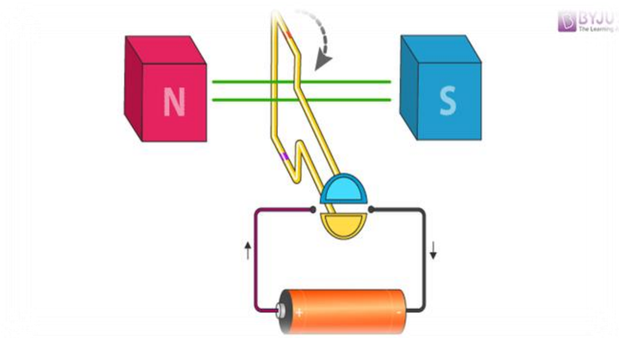


Figure 5.7: Permanent magnet moving coil

A left hand can be held, as shown in figure 5.8 , so as to represent three mutually orthogonal axes on the thumb, fore finger and middle finger [35].

Each finger is then assigned to a quantity (mechanical force, magnetic field and electric current). The right and left hand are used for generators and motors respectively [35].

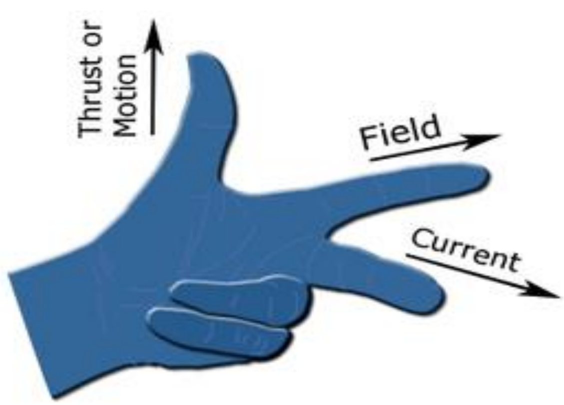


Figure 5.8: Fleming left hand rule

5.3 Classification of motors

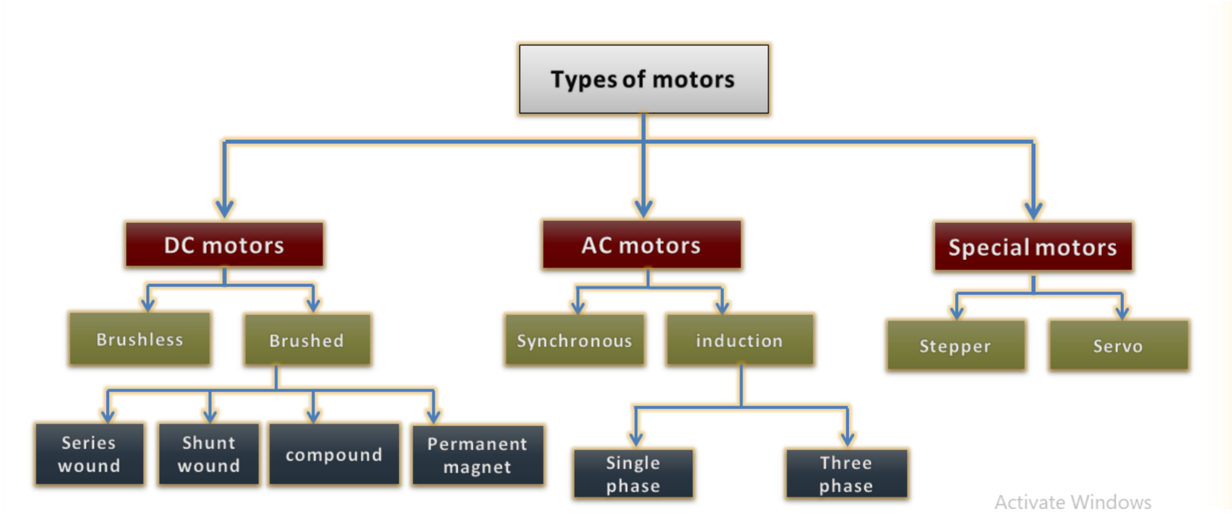


Figure 5.9: Classification of motors

5.3.1 DC motors

DC motors were the first type of engine widely used and the initial costs of the systems (motors and drives) tend to be generally lower than AC systems for low power units, but with higher power the overall maintenance costs increase and should be taken into account. DC Motor speed can be controlled by varying the supply voltage and are available in a wide range of voltages, although the most popular type is 12 & 24V, with some of the advantages:

- Easy installation
- Speed control over a wide range
- Quick Starting, Stopping, Reversing and Acceleration
- High Starting Torque
- Linear speed-torque curve

➢ **Classifications of DC motors**

1. Less costs than AC systems for low power units less than 12 watt.
2. The DC Motors speed can be controlled by varying the supply voltage.
3. Easy installation.
4. Speed control over a wide range 1-20000 rpm.
5. Quick Starting, Stopping, Reversing and Acceleration.
6. High Starting Torque.
7. Linear speed-torque curve.
8. It has lesser reactive power consumption than AC Motors

5.3.1.1 Brushed DC motors

Brushed DC motors shown in figure 5.10 are the more traditional type of engine and are typically used in cost sensitive applications where the control system is relatively simple [27].

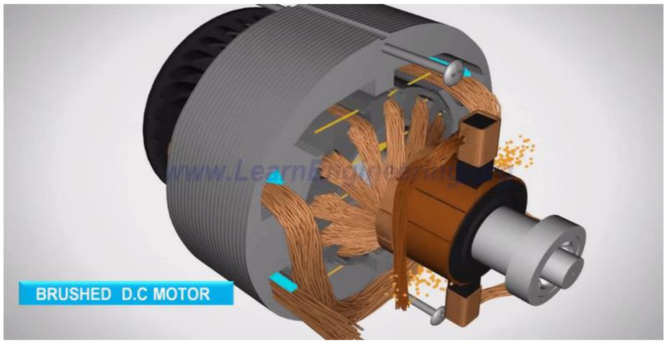


Figure 5.10: Brushed DC motors

For example, in consumer applications and more basic industrial equipment, these types of engines can be broken down as if they were used:

5.3.1.1.1 Series Wound

Series wound shown in figure 5.10 is where the field winding is connected in series to the rotor winding and the speed control is by varying the supply voltage, but this type offers poor speed control and, as the engine torque increases, the speed drops. Applications include automobiles, hoists, lifts and cranes, as they have a high starting torque [27].

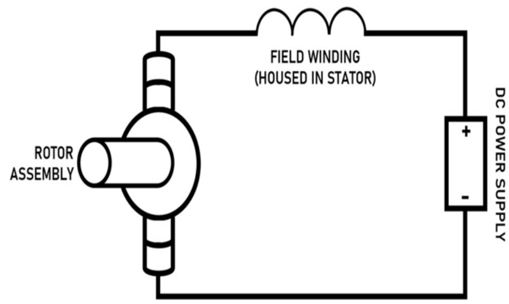


Figure 5.11: Series wound

5.3.1.1.2 Shunt Wound

This type as shown in figure 5.12 has one voltage supply and the field winding is connected parallel to the winding of the rotor and can deliver increased torque without reducing the speed by increasing the current of the engine. It has a medium starting torque at constant speed, making it suitable for applications such as lathes, vacuum cleaners, conveyors and grinders [27].

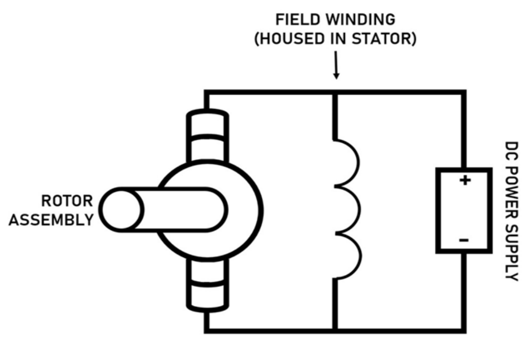


Figure 5.12: Shunt wound

5.3.1.1.3 Compound Wound

Compound wound shown in figure 5.13 is a cumulative of the Series and Shunt, where the polarity of the shunt winding is so great that it adds to the field series. This type has a high starting torque and operates smoothly when the load varies slightly and is used for driving compressors, variable-head centrifugal pumps, rotary presses, circular saws, scissors, elevators and continuous conveyors [27].

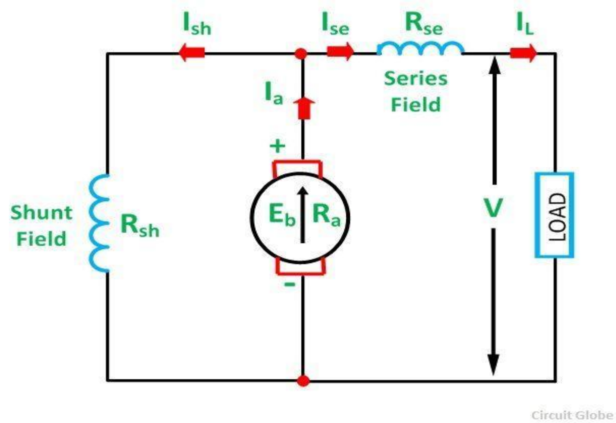


Figure 5.13: Compound wound

5.3.1.2 Brushless DC motors

Brushless motors as shown in figure 5.14 reduce some of the problems associated with more common brushed motors (short life span for high-use applications) and are mechanically much easier to design (not having brushes). The engine controller uses the Hall Effect sensors to detect the position of the rotors, which enables the controller to control the motor precisely via the current in the rotor coils) in order to control the speed. The advantages of this technology are long life, low maintenance and high efficiency (85-90%), while the disadvantages are higher initial costs and more complicated controllers. These types of engines are generally used for speed and position control in applications such as fans, pumps and compressors where reliability and robustness are required [27].

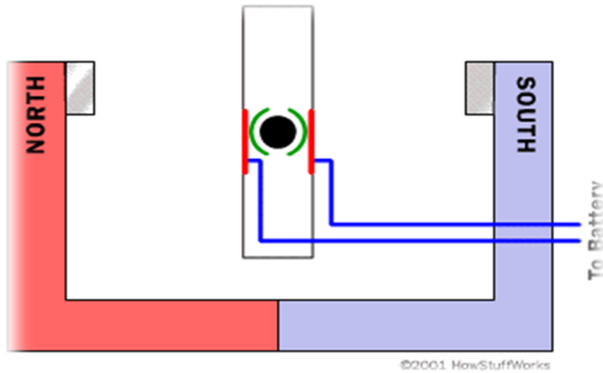


Figure 5.14: Brushless motor

5.3.1.3 Brushless motors VS Brushed motors

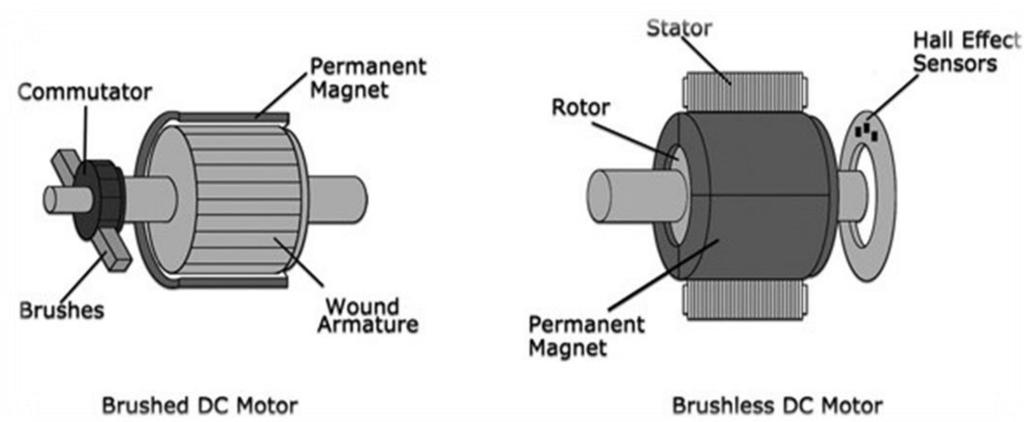


Figure 5.15: Brushed and brushless Dc motors

Table 5.1: Comparison between brushed motor and Brushless motor

Characteristic	Brushed Motor	Brushless Motor
Wiring/control	Only a power source is needed and can be connected directly to the motor.	Require a controller with the ability to monitor the position of the motor shaft and control the electromagnets

	Speed is controlled by varying the voltage applied. No specialized control circuitry is required.	accordingly.
Efficiency	75-80%	85-90%
Cost	Simple and inexpensive	More expensive and also require the purchase of a controller.
Torque	Less torque	More torque per weight and per watt.
Speed	Mechanical electrical contacts limits speed.	Higher speed due to lack of mechanical electrical connections.

5.3.1.4 DC Brushless fan

Brushless DC fan uses brushless DC motors (BLDC motor) that have a cross pattern arrangement of four permanent magnets mounted on the sides of the rotor. Unlike brushed DC motors, BLDC motors do not require any commutator or brushes to operate [46].

The brushless DC fan is a combination of a powerful BLDC motor, shaft, and fan blades. These fans are durable, reliable, and highly energy efficient. They do not produce sparks in the circuit and operate noiselessly [46].

Brushless DC fans are called "brushless" because the electric motor within the fan is commutated electronically. Older DC fans used mechanical brushes, which can cause increased electromagnetic interference (EMI) along with dust particles due to mechanical wear throughout the system.

Over time, the fan would wear and eventually fail. Brushless fans have replaced these mechanical brushes with electronic sensors and switches that now perform the necessary commutation. This commutation circuitry is mounted within the fan itself and is totally transparent to the user. The end result is a simple to use, reliable, 2-wire device. This has greatly increased the lifetime and the reliability of these fans [46].

The initial torque produced in DC motors is quite high, and hence, brushless DC fans reach their full potential in no time. Their speed can be controlled merely by increasing or decreasing the voltage input[46].

Fig 5.16: Brushless DC fan

Brushless DC fans are classified into two categories [46]:

- **BLDC fan with Sensor Motor**: These fans are equipped with a sensor called the half effect sensor that aids in detecting the position of the magnet.

- **BLDC fan with Sensor-less Motor**: In these fans, back EMF is used to detect the position of the magnet.

5.3.2 Stepper motors

A stepper motor shown in figure 5.17 is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation. Its normal shaft motion consists of discrete angular movements of essentially uniform magnitude when driven from sequentially switched DC power supply [29].

The stepper motor is a digital input-output device. It is particularly well suited to the type of application where control signals appear as digital pulses rather than analog voltages. One digital pulse to a stepper motor drive or translator causes the motor to increment one precise angle of motion. As the digital pulses increase in frequency, the step movement changes into continuous rotation [29].

Like all electric motors, it has a rotor and a stator. The rotor is a movable part without windings, brushes and switches. Usually the rotors are either variable or permanent magnet type. The stator is often constructed with multi-pole and multi-phase windings, usually three or four phase windings for the required number of poles determined by the desired angular displacement per input pulse [32].

Unlike other engines, it operates on a programmed discrete control pulse, which is applied to the stator windings by means of an electronic drive. The rotation is due to the magnetic interaction between the poles of the sequentially energized stator winding and the poles of the rotor [32].

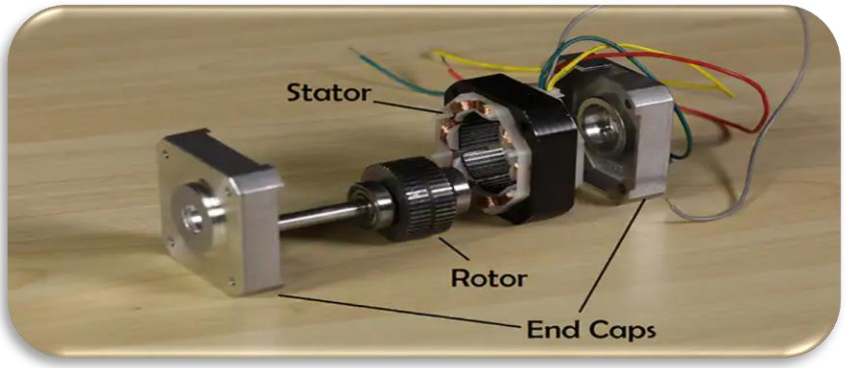


Figure 5.17: Stepper motors

5.3.2.1 Working principle of stepper motors

The stepper motor rotor is a permanent magnet, when the current flows through the stator winding, the stator winding to produce a vector magnetic field. The magnetic field drives the rotor to rotate by an angle so that the pair of magnetic fields of the rotor and the magnetic field direction of the stator are consistent [36].

When the stator's vector magnetic field is rotated by an angle, the rotor also rotates with the magnetic field at an angle. Each time an electrical pulse is input, the motor rotates one degree further. The angular displacement it outputs is proportional to the number of pulses input and the speed is proportional to the pulse frequency. Change the order of winding power, the motor will reverse. Therefore, it can control the rotation of the stepping motor by controlling the number of pulses, the frequency and the electrical sequence of each phase winding of the motor [36].

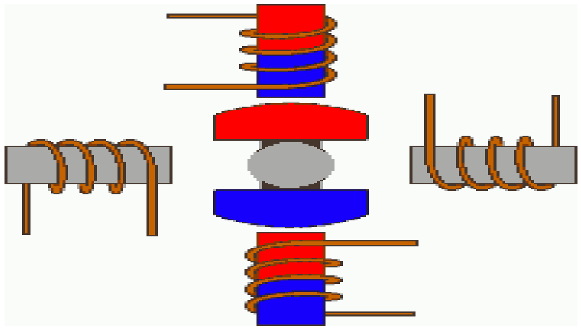


Figure 5.18: Working principle of stepper motor

5.3.2.2 Bipolar and unipolar stepper motors

5.3.2.2.1 Unipolar stepper

The unipolar stepper motor shown in figure 5.19 operates with one winding with a center tap per phase. Each section of the winding is switched on for each direction of the magnetic field [34].

Each winding is made relatively simple with the commutation circuit, this is done since the arrangement has a magnetic pole which can be reversed without switching the direction of the current. In most cases, given a phase, the common center tap for each winding is the following; three leads per phase and six leads for a regular two-phase stepper motor [34].

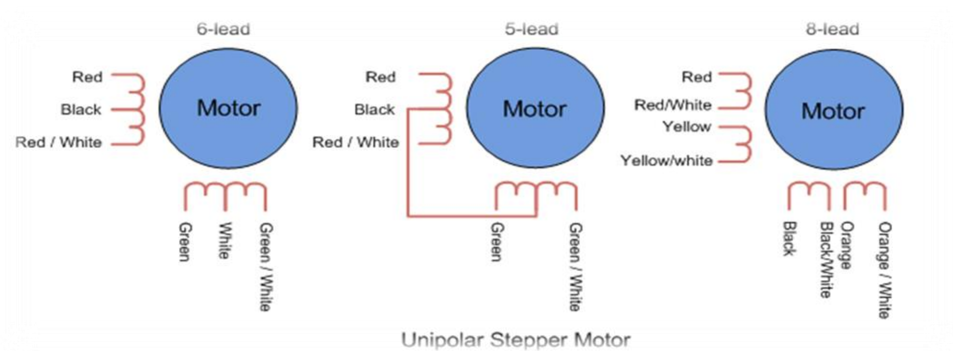


Figure 5.19: Unipolar stepper motor

5.3.2.2.2 Bipolar stepper motor

Bipolar stepper motors shown in figure 5.20, there is only a single winding per phase. The driving circuit needs to be more complicated to reverse the magnetic pole, this is done to reverse the current in the winding. This is done with an H-bridge arrangement, however, there are several driver chips that can be purchased to make this a more simple task [34].

Unlike the unipolar stepper motor, the bipolar stepper motor has two leads per phase, neither of which are common. Static friction effects do happen with an H-bridge with certain drive topologies, however, this can be reduced by dithering the stepper motor signal at a higher frequency[34].

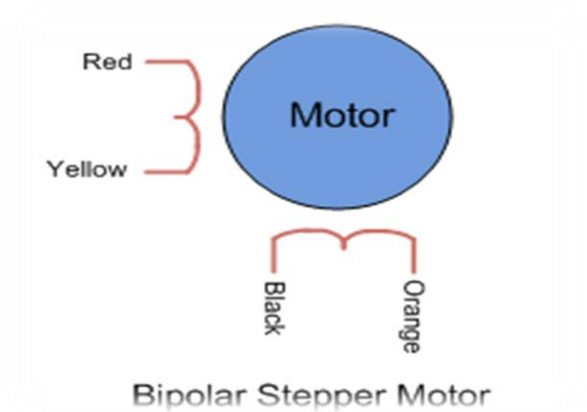


Figure 5.20: Bipolar stepper motor

5.3.2.3 Step sequence of stepper motor

5.3.2.3.1 Full step sequence

In two-phase on full step shown in figure 5.21, the motor is operated with both phases energized at the same time. This mode provides improved torque and speed performance. Two-phase on provides about 30% to 40% more torque than one phase on, however it requires twice as much power from the driver [33].

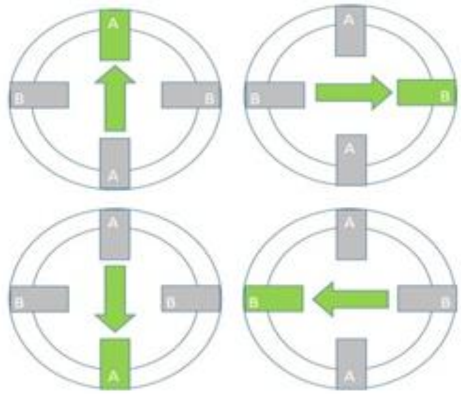


Figure5.21: full step sequence

5.3.2.3.2 Half step sequence

Half step excitation mode shown in figure 5.22 is a combination of one phase on and two phase on full step modes. This results in half the basic step angle. This smaller step angle provides smoother operation due the increased resolution of the angle [33].

Half step produces about 15% less torque than two phase on - full step, however modified half stepping eliminates the torque decrease by increasing the current applied to the motor when a single phase is energized [33].

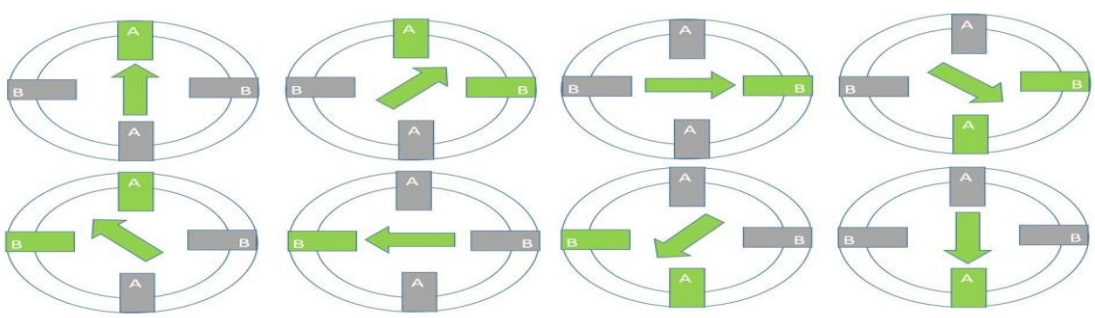


Figure 5.22: Half step sequence

5.3.2.4 The Stepper Motor importance in digital applications

- **Industrial Machines**

  Automotive gauges and automated assembly machine tooling are used for stepper motors [12].

- **Security**

  New security industry surveillance devices [38].

- **Medical Stepper motors**

  Stepper motors are used in medical scanners, samplers and also in digital dental photography, in fluid pumps and breathing machines, as well as in blood analysis machines [38].

- **Consumer Electronics**

  Stepper motors for auto focusing and zooming digital camera work in cameras [38].

Stepper motor control circuit is a low cost and very simple circuit, mainly used in low power applications. Which consists of 555 timers IC used as a stable multi vibrator [38].

5.3.3 Servo motors

Servo motors are motors capable of providing very precise motion control. The feedback in a servo motor system as shown in figure 5.23 senses the difference between the actual and desired speed or position so that the controller can adjust the output to correct any drift from the target position [31].

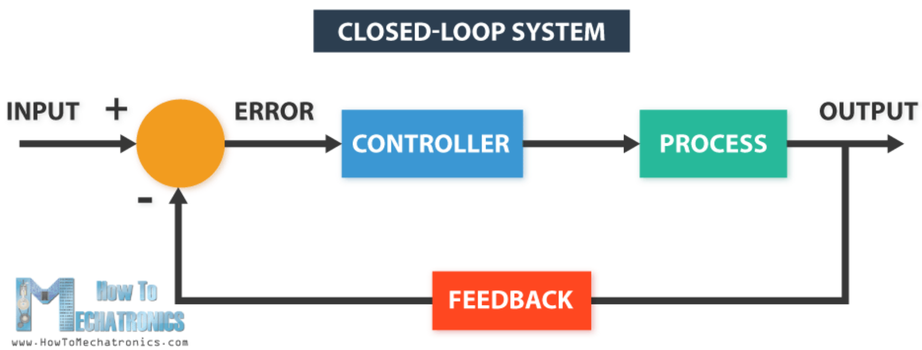


Figure 5.23: Block diagram for servo motors

5.3.3.1 Types of servo motors

Generally, there are two main types of this motor based on the supply used for its function. They are **AC servo motors** & **DC servo motors** as shown in figure 5.24.

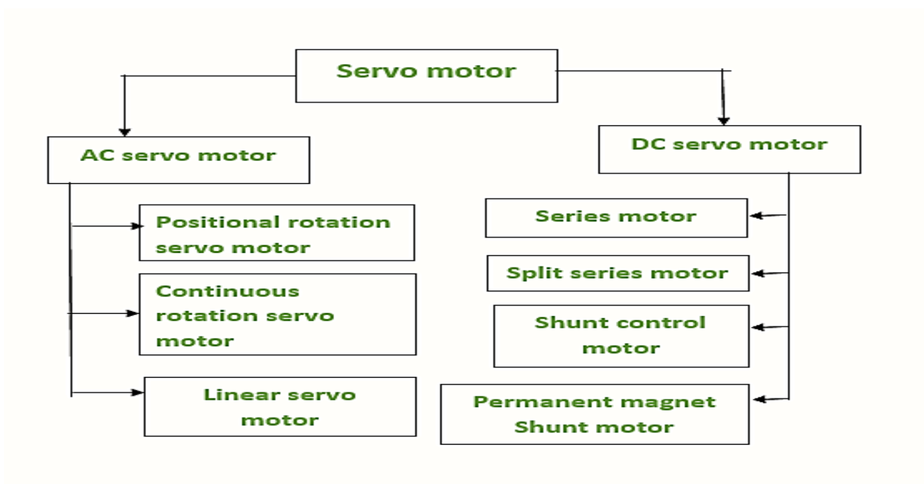


Figure 5.24: Types of servo motor

- **DC Servo Motor**

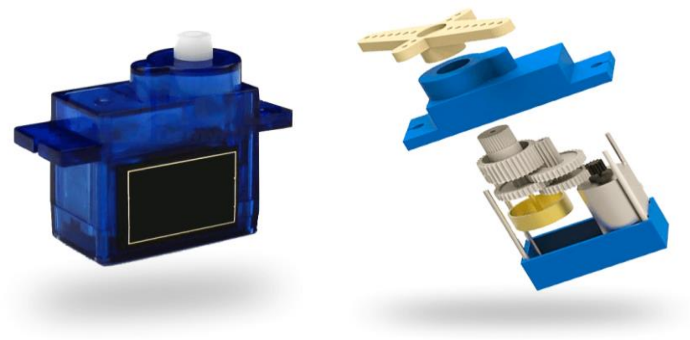


Figure 5.25: DC servo motors

Generally, the DC servo motor shown in figure 5.25 includes a DC source separately in the armature winding field. The engine can be controlled by either the field current or the armature current. The control of the armature and the field control have advantages. This engine offers a quick and accurate response to start or end signals due to a small inductive armature. They are used in a number of devices and numerically controlled equipment[31].

- **Series servo motor**

Series servo motors have a high starting torque as well as a huge current. The speed regulation of this engine is much lower. Turnaround can be achieved by reversing the field voltage polarity using split series field winding[31].

- **Split series servo motor**

Split series engines can act as an individually energized field controlled engine. The engine armature supplies a stable supply of current. This engine has a common torque velocity curve. This specifies a high stall torque and a rapid decrease in torque by amplifying the speed[31].

- **Shunt Control Motor**

The shunt control engine consists of two windings, such as field windings and armature windings. Field windings are located on the stator, while the armature windings are located on the rotor of the machine. In the DC shunt motor, the two windings connect parallel to the DC source[31].

5.3.3.2 Working principle of servo motors

The simplicity of a servo is one of the features that makes it so efficient. The heart of a servo is a small direct current (DC) engine, similar to what you would find in a cheap toy. These engines are powered by the battery and spin at a high RPM, but release a very low torque (a twisting force used to work you apply torque when you open a jar). The configuration of the gears takes the engine's high speed and slows it down while at the same time increasing the torque. A tiny electric motor doesn't have a lot of torque, but it can actually spin hard (small force, big distance). The gear design within the servo shown in figure 5.25 converts the output to a much slower rotational speed, but with a higher torque (big force, little distance). The actual amount of work is the same, only more useful. Gears in a low-cost servo motor are usually made of plastic to make them lighter and less costly. On a servo designed to provide more torque for heavy operation, the gears are made of metal and are more difficult to damage [28].

Figure 5.26: The gears in a typical standard size servo are made of plastic and convert the fast, low-power motion of the motor to the output shaft

With a tiny DC motor, you use battery power and the engine spins. However unlike a simple DC motor, the servo's rotating motor shaft slows down with the gears. The location sensor on the final gear is attached to a small circuit board. The sensor informs the circuit board how much the servo output shaft has rotated. The electronic input signal from a computer or a radio in a remote-controlled vehicle is also fed into the circuit board [28].

The electronics on the circuit board shown in figure 5.26 decode the signals in order to decide how much the consumer wants the servo to spin. It then compares the desired position to the actual position and determines which way to rotate the shaft to the desired position [28].

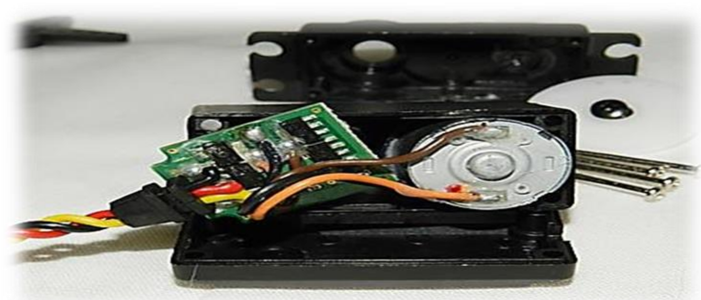


Figure 5.27: The circuit board and DC motor in a high-power servo

5.3.3.3 Construction of servo motors

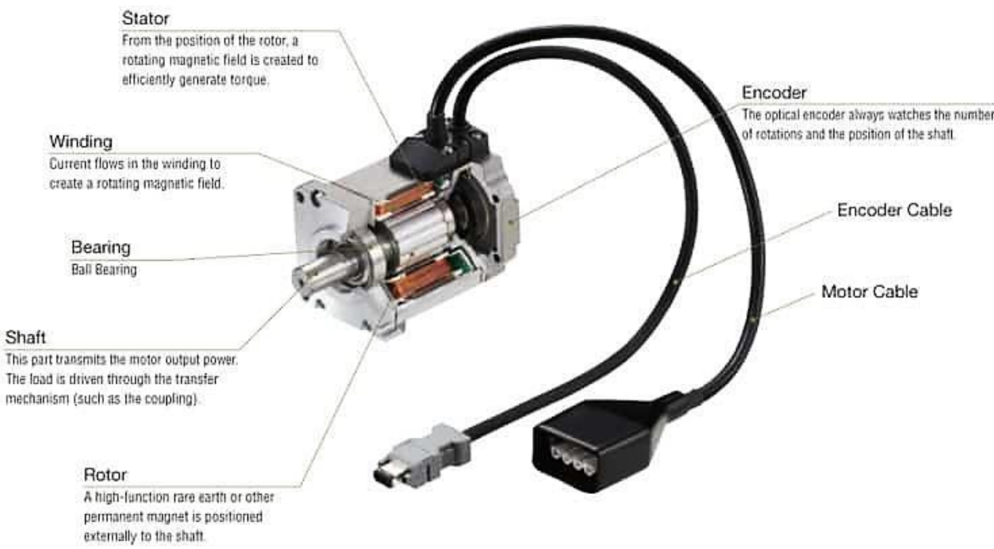


Figure 5.28: Construction of servo motors

The servo motor consists of two winding stators and a rotor winding as shown in figure 5.28. The winding of the stator is wound to the stationary part of the engine, and this winding is also called the winding of the engine. The winding of the rotor is wound to the rotating part of the engine, and this winding is also called the winding of the engine. The engine consists of two front and back bearings for free movement of the shaft. The encoder has the approximate sensor for determining rotational speed and revolution per minute of the motor [28].

5.3.3.4 Servo motor control

In a conventional analog servo motor a PWM signal with a period of 20 ms is used to control the motors. A signal of 20 ms has a frequency of 50 Hz [37].

The width of the pulse is varied between 1 and 2 ms to control the motor shaft position [11].

- A pulse width of 1.5ms will cause the servo shaft to rest in the 90 degree position, the center of its travel.

- A pulse width of 1ms will cause the servo shaft to rest at the 0 degree position.
- A pulse width of 2ms will cause the servo shaft to rest in the 180 degree position.

Varying the pulse width between 1ms and 2ms will move the servo shaft through the full 180 degrees of its travel as shown in figure 5.28. You can bring it to rest at any angle you desire by adjusting the pulse width accordingly [37].

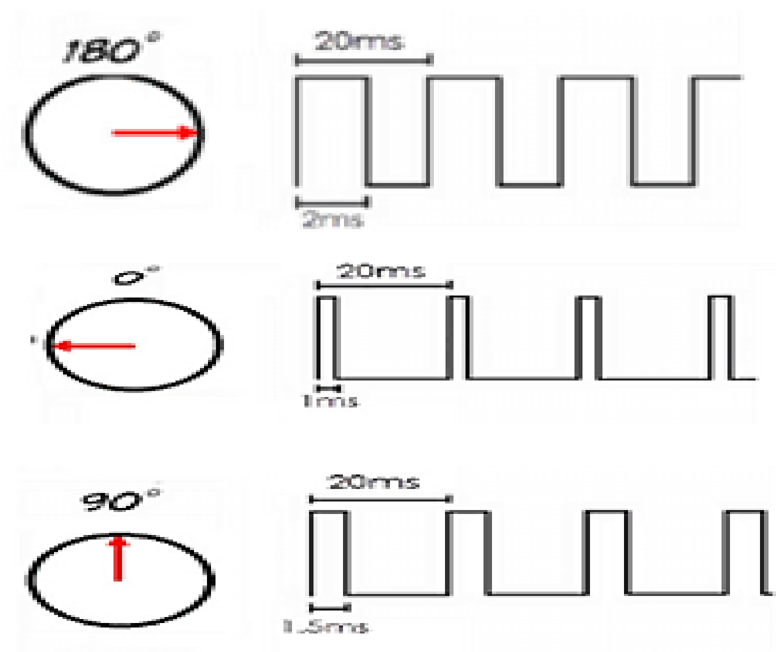


Figure 5.29: Servo motor PWM duty cycle

5.3.3.5 The Servo Motor importance in digital applications:

- **Servo Motor in Robotics**

The motors used to drive the joints are servo motors to pick an object from position A and place it in position B. This is because, to complete this function of picking and position, we have to plan the angular motion of each joint [28].

The robot will continue its function once these data are filled to the robot controller. The controller sends PWM data to each robot engine. This ensures that the arm is precisely positioned and cannot be operated using a standard DC motor. In electronics projects the use of servomotors can be observed in robotics at a small scale. A tiny servo motor would be the best Arduino starter kits [28].

- **Servo Motor Applications in Camera Auto Focus**

Modern digital cameras today are very smart. The ability to auto focus on the item being filmed is one of the advanced features. When the object image is generated within the camera's digital signal processor, sharpness is checked. Basically, the picture seems to be blurred if the focal length (measured by the camera lens) is not correct. The remedial action is taken by a highly accurate servo motor inside the camera to accurately position the lens so the sharpest image can be captured. Another example of important servo motor applications is this [28].

- **Servo Motor in Robotic Vehicles**

Robotic vehicles today which use servo motors for rolling wheel applications in highly complex military and industrial applications. The angular movement here is not important as the servo used is a continuous servo rotation. What is important is the ability of the servo to produce enough torque to shut the vehicle quickly and to stop it fast. You can also control the speed at which the vehicle is to move [28].

5.3.4 Pumps

Pumps are used to transfer and distribute liquids in various industries. Pumps convert mechanical energy into hydraulic energy. Electrical energy is generally used to operate the various types of pumps [45].

➢ **Pumps have two main purposes[45]**.

- Transfer of liquid from one place to another place (e.g. water from an underground into a water storage tank).
- Circulate liquid around a system (e.g. cooling water or lubricants through machines and equipment).

5.3.4.1 Components of a Pumping System[45]

- Pump casing and impellers
- Prime movers: electric motors, diesel engines or air system
- Piping used to carry the fluid
- Valves, used to control the flow in the system
- Other fittings, controls and instrumentation
- End-use equipment, which have different requirements (e.g. pressure, flow) and therefore determine the pumping system components and configuration. Examples include heat exchangers, tanks and hydraulic machines.

5.3.4.2 Classification[45]

There exist a wide variety of pumps that are designed for various specific applications. However, most of them can be broadly classified into two categories as mentioned below.

❖ positive displacement

❖ dynamic pressure pump

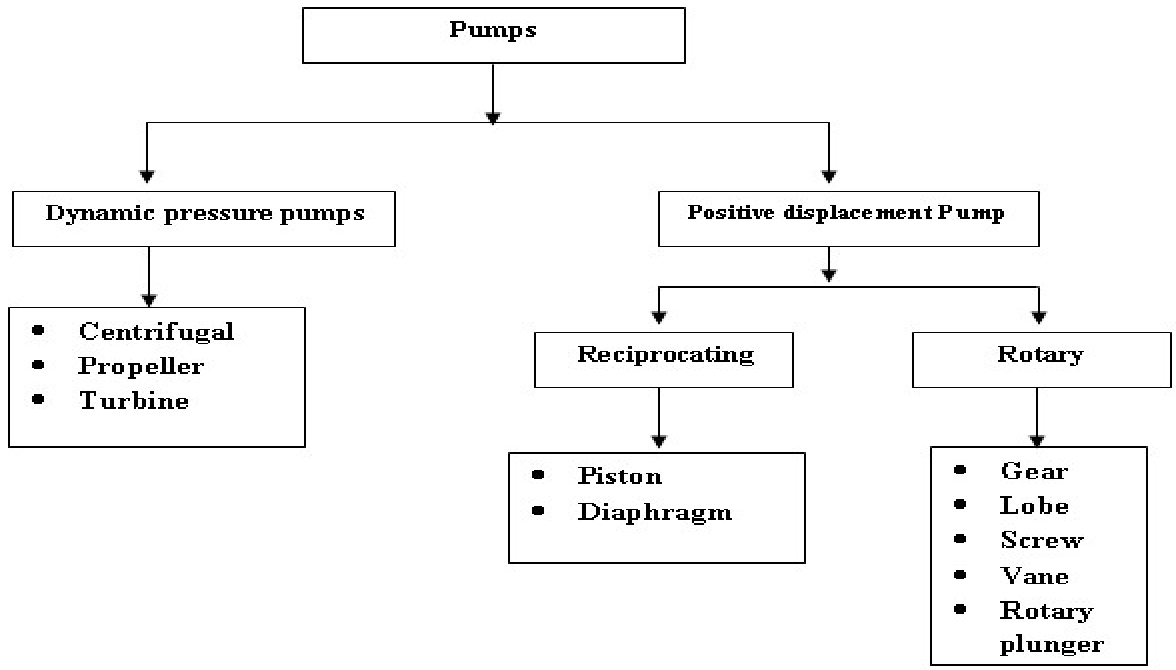


Figure 5.30: classification of pump

5.3.4.3 Positive Displacement Pumps

The term positive displacement pump is quite descriptive, because such pumps are designed to displace a more or less fixed volume of fluid during each cycle of operation. The volumetric flow rate is determined by the displacement per cycle of the moving member (either rotating or reciprocating) times the cycle rate (e.g. rpm). The flow capacity is thus fixed by the design, size, and operating speed of the pump. The pressure (or head) that the pump develops depends upon the flow resistance of the system in which the pump is installed and is limited only by the size of the driving motor and the strength of the parts. Consequently, the discharge line from the pump should never be closed off without allowing for recycle around the pump or damage to the pump could result. They can be further classified as:

5.3.4.4.8 Dynamic Pressure Pumps

In dynamic pressure pump, during pumping action, tangential force is imparted which accelerates the fluid normally by rotation of impeller. Some systems which contain dynamic pump may require positive displacement pump for priming. They are normally used for moderate to high discharge rate. The pressure differential range for this type of pumps is in a range of low to moderate. They are popularly used in a system where low viscosity fluids are used [45].

5.3.4.4.9 Centrifugal pumps

They use a rotating impeller to increase the pressure of a fluid. Centrifugal pumps are commonly used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits into the downstream piping system. Centrifugal pumps are used for large discharge through smaller heads. These types of pumps are used for supply of water and handling of milk in dairy plants[45].

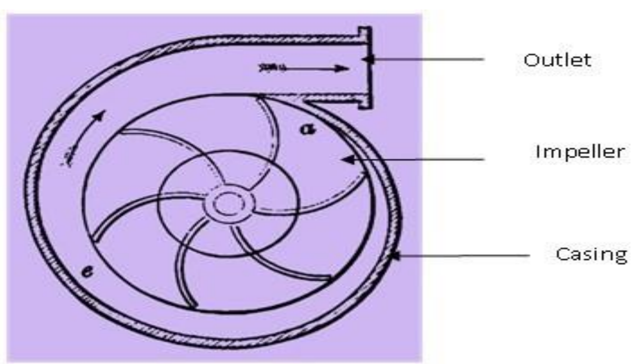


Figure 5.31: centrifugal pump

5.3.4.4.10 Propeller pump

A propeller pump is a high flow, low lift impeller type device featuring a linear flow path. The propeller pump may be installed in a vertical, horizontal, or angled orientation and typically has its motor situated above the water level with the impeller below water. These pumps function by drawing water up an outer casing and out of a discharge outlet via a propeller bladed impeller head[45].

- **How to choose a pump[45]**

There are some factors need to be considered while selecting the pump that includes the following.

Material: The pump material should be weather-resistant for exposed uses.

Power: The power of the pump mainly includes horsepower & the flow rate.

Type of Fuel and Motor: The motor and fuel of the pump should be electric motor, gas, hydraulic, diesel, otherwise manual.

Head: The total head expulsion, otherwise utmost pump power, appropriate for the proposed application

5.3.5 Applications of Water Pumps

Water pumps are used for dewatering reasons decreasing the downtime from huge rain events. The common applications of these pumps include buildings, wells, boost application, circulation of hot water, sump pits, protection of fire systems.

Thus, this is all about water pumps which are frequently used in construction fields for removing surplus water as well as dewatering.

Because of heavy rains, the flow of water can increase & water pumps let you supply the water rapidly to reduce downtime. These pumps are appropriate for applications like electric, hydraulic, gas-powered, and otherwise manual.

These pumps are vast addition to our life because they make possible a huge variety of industrial, agricultural and household tasks. But, the variety of water pumps in the marketplace is so adaptable and plentiful that selecting the correct pump appropriate for your requirements is challenging [45].

Chapter 6

Wireless module

A wireless module is a small electronic device built into objects, machines, and things that connect to wireless networks that send and receive data.

6.1 Wireless modules

6.1.1 Bluetooth module

A Bluetooth module shown in fig 6.1 is usually a hardware component that provides a wireless product to work with the computer; or in some cases, the bluetooth may be an accessory or peripheral, or a wireless headphone or other product (such as cellphones can use) [39].

Fig 6.1: Bluetooth module

Bluetooth shown in figure 6.2 is a specification (IEEE 802.15.1) for the use of low-power radio communications to link phones, computers and other network devices over short distances without wires [39].

The name Bluetooth is borrowed from Harald Bluetooth, a king in Denmark more than 1,000 years ago.

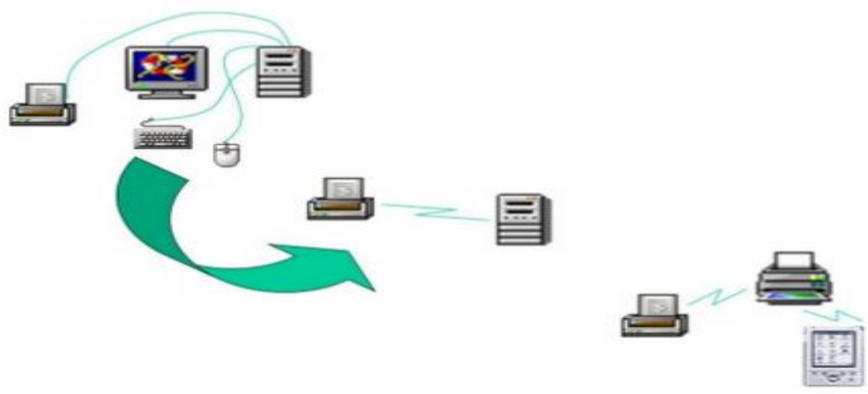


Fig 6.2: Bluetooth

6.1.1.1 General specifications

- Short range wireless connectivity.
- Low power consumption
- Automatic recognition.
- Bluetooth technology was designed primarily to support simple wireless networking of personal consumer devices and peripherals, including cell phones, and wireless headsets.
- Wireless signals transmitted with Bluetooth cover short distances, typically up to 10 meters.
- Bluetooth devices generally communicate at less than 1Mbps
- Bluetooth networks feature a dynamic topology called a personal area networks (PAN), up to 8 devices.

6.1.1.2 sending data from bluetooth to arduino

Module has an internal 3.3v regulator and that is why you can connect it to 5v voltage. But we strongly recommend to use a 3.3V voltage, since the logic of HC05 serial communication pins is 3.3V. Supplying 5V to the module can cause damage to the module. In order to prevent module from damages and make it work properly, you should use a resistance division circuit (5v to 3.3v) between arduino TX pin and module RX pin. When master and slave are connected, blue and red LEDs on the board blink every 2seconds.If they aren't connected, only blue one blinks every 2 seconds [40].

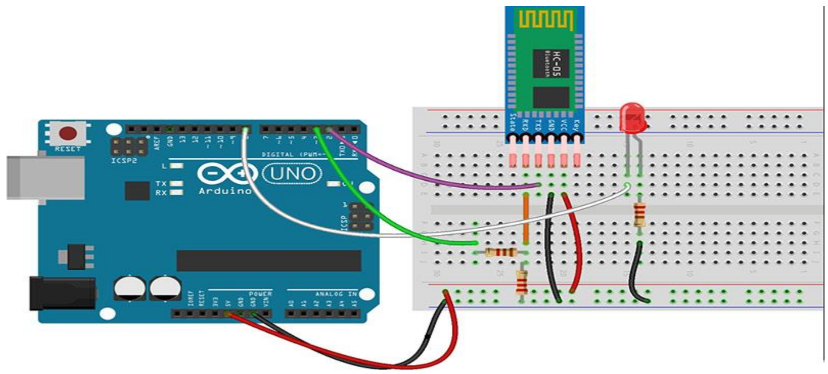


Fig 6.3: Interfacing HC-05 Bluetooth Module with Arduino UNO

6.1.1.3 Pin layout

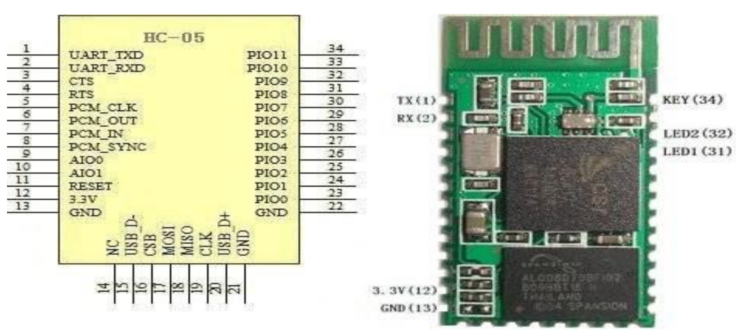


Fig 6.3: Pin layout of bluetooth module

6.2 WI-FI Module

WiFi module shown in figure 6.4, also known as serial to WIFI module, which belongs to the transmission layer of IoT. The function is to convert serial port or TTL level into embedded module which can conforming to WiFi wireless network communication standard, with built-in wireless network protocol IEEE802.11 B.G.N protocol stack and TCP/IP protocol stack.

Traditional hardware devices embedded WIFI modules can use WIFI directly to connect to the Internet, which is an important part of realizing wireless smart home, M2M and other IoT applications.

6.2.1 Applications of WIFI module

- Serial port (RS232/RS485) to WiFi, TTL to WiFi.
- WiFi monitoring, TCP/IP and WIFI coprocessor.
- WiFi remote control aircraft, cars and other toys.
- WiFi network radio, camera, digital photo frame.
- Medical devices, data acquisition and handheld devices.
- WiFi fat scale, smart card terminal, Intelligent home.
- Instrument, equipment parameter monitoring, wireless POS machine;
- Modern agriculture, military field and other wireless related secondary development applications.

6.2.2 ESP8266 WiFi module

ESP8266 module allows to use RemoteXY with microcontroller device for Wi-Fi. Implemented support for all Arduino boards [41].

RemoteXY allows to configure module for operate in one of two modes: access point and client. Client allows to connect the module to an existing Wi-Fi access point [41].

Access point mode of ESP8266 configures the module as an access point and allows to connect Arduino directly to this point. The access point is available to connect to it from smartphone or tablet within a radius of availability of the radio signal. It does not require any other network infrastructure. This connection mode can be used in the far away place where there is no computer networks and the Internet. To configure this mode in the configuration properties of editor need to select the type of connection "Wi-Fi access point."

Client mode of ESP8266 configures the module for automatically connect to an existing Wi-Fi access point, such as a home router or enterprise access point. At the same time connected to the Arduino module ESP8266 must be located in the physical availability of the radio signal of access point. Connecting to the device from smartphone or tablet will be not directly, but through the Ethernet network, an IP address provided by the DHCP server to ESP8266 module. It allows to connect to the Arduino device from anywhere in the local network as well as from the Internet. Connect from the Internet is possible with the correct configuration of the router, such as the use of the virtual server. To configure this mode in the configuration properties of editor need to select the connection type "Ethernet" and select ESP8266 module.

Power of module can be provided from the DC-DC of Arduino board to 3.3V. Some boards, such as Arduino Nano can not provide sufficient power to output 3.3V, in this case, you need a separate power supply [41].

6.2.2.1 Interfacing diagram

The module is connected to the microcontroller board as shown inn fig 6.5 via serial interface. You can choose to use software serial or hardware serial. Module connection option is selected in the module interface settings of editor. The module is controlled via AT commands [41].

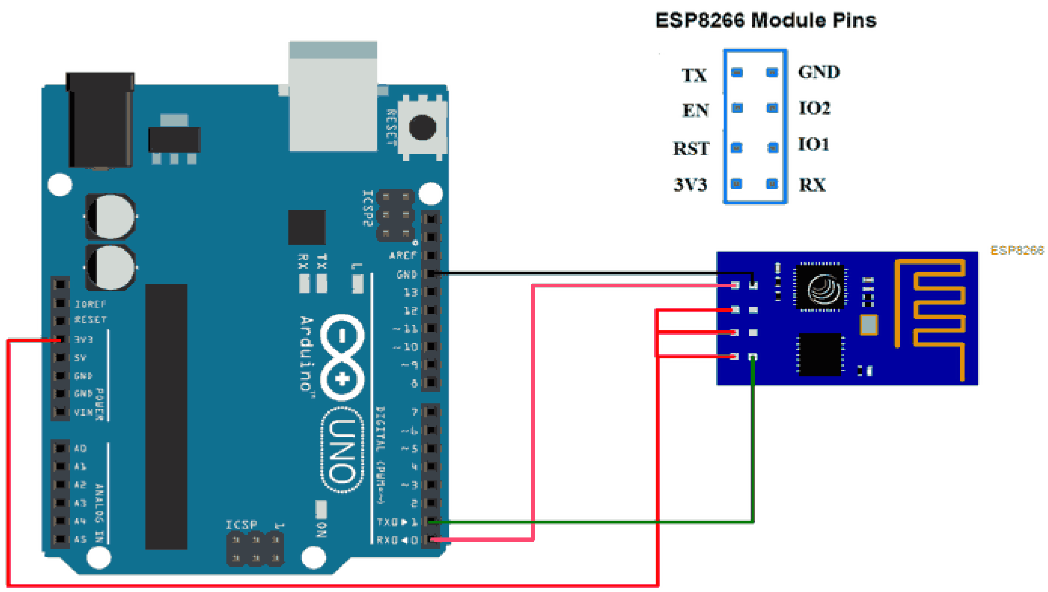


Fig 6.5: Interface diagram

6.2.2.1.1 Connection with software

It allows to connect the module to an arbitrary microcontroller pins. The pins used must be select in the module interface settings of editor. Also in the settings must be select the baud rate for serial port. ESP8266 default configured to 115200 baud. To work through Software Serial, must configure the transmission speed ESP8266 to a lower speed. Stable operation of the module is possible at a speed of no more than 19200 baud. To change the speed of module serial interface, must to connect it to the console to the possibility of the AT commands. Module serial interface speed can be changed with the AT command "AT+UART_DEF=19200,8,1,0,0" [41].

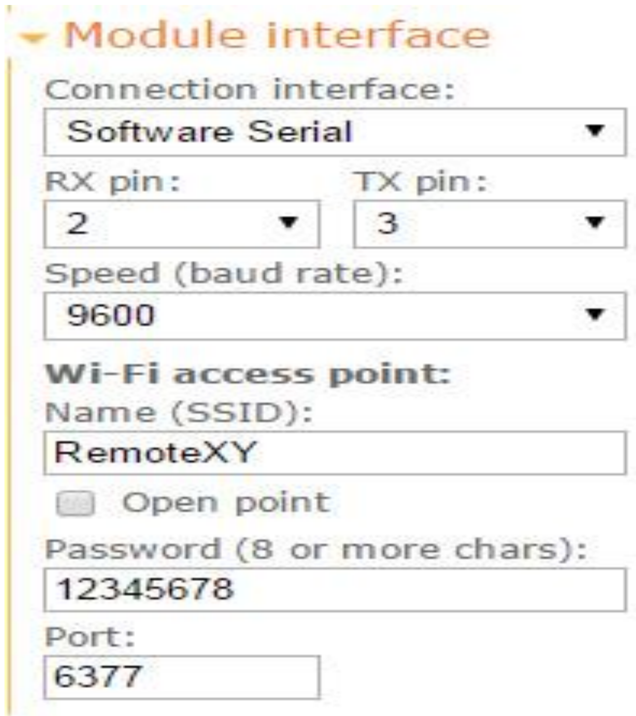


Fig 6.6:Module interface of hardware connection

There are some limitations on the use of the RX pin for Arduino boards. Limitations associated with do not support to pins interrupt of the microcontroller.

- On **Arduino** RX doesn't work on pin 13.
- On **Mega** and **Mega2560** only the following can be used for RX: 10, 11, 12, 13, 14, 15, 50, 51, 52, 53, A8(62), A9(63), A10(64), A11(65), A12(66), A13(67), A14(68), A15(69).
- On **Leonardo** and **Micro** only the following can be used for RX: 8, 9, 10, 11, 14, 15, 16.

Also, when using Software Serial you should take the following limitations:

- No ability to work at high baud rates. It is not recommended to use a baud rate of more than 19200.
- Some libraries, which also uses interrupt may not work correctly.

6.2.2.1.2 Connection with hardware

It allows to connect the module to the microcontroller pins, supporting one of the hardware serial ports. For different Arduino boards are different ports and contacts. Hardware serial allows to work module at a maximum connection speed of 115200 baud. The baud rate for Arduino is selected in the module interface settings of editor. ESP8266 must be to preconfigured to work at the same speed as the Arduino. The baud rate setting of module can be made via AT commands. Next Arduino serial ports are available:

- **Arduino UNO and Nano**: Serial (RX-0, TX-1);
- **Arduino MEGA and MEGA2560**: Serial (RX-0, TX-1), Serial1 (RX-19 и TX-18), Serial2 (RX-17 и TX-16), Serial3 (RX-15 и TX-14);

Which port to use, and therefore the pins should be connected to the module, you must select in interface settings of editor. It should also be borne in mind that for Arduino boards Serial port enabled for the microcontroller programming, and if you decide to use this port, you must disconnect the ESP8266 module when programming it. A good solution is to use the boards Arduino MEGA any port other than Serial [41].

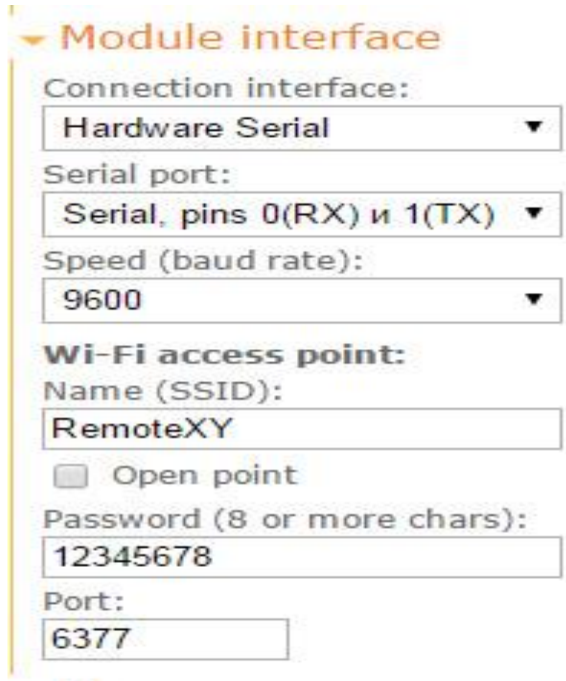


Fig 6.7:Module interface of software connection

6.3 GSM/GPRS module

A GSM module or a GPRS module is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a GSM or GPRS system. The modem (modulator-demodulator) is a critical part here.

These modules consist of a GSM module or GPRS modem powered by a power supply circuit and communication interfaces (like RS-232, USB 2.0, and others) for computer. A GSM modem can be a dedicated modem device with a serial, USB or Bluetooth connection, or it can be a mobile phone that provides GSM modem capabilities.

GSM/GPRS module is used to establish communication between a computer and a GSM-GPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB) for computer. The MODEM is the soul of such modules [42].

6.3.1 The difference between modems, modules and mobiles

A GSM module or GPRS modules are similar to modems, but there's one difference: A GSM/GPRS Modem is an external equipment, whereas the GSM/GPRS module is a module that can be integrated within an equipment. It is an embedded piece of hardware.

A GSM mobile, on the other hand, is a complete system in itself with embedded processors that are dedicated to provide an interface between the user and the mobile network [42].

6.3.2 Modems

Wireless modems generate, transmit or decode data from a cellular network, in order to establish communication.

A GSM/GPRS modem is a class of wireless modem, designed for communication over the GSM and GPRS network. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. Also, they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification [42].

1. The MODEM needs **AT commands**, for interacting with processor or controller, which are communicated through serial communication.
2. These commands are sent by the controller/processor.
3. The MODEM sends back a result after it receives a command.
4. Different AT commands supported by the MODEM can be sent by the processor/controller/computer to interact with the GSM and GPRS cellular network.

It's functions include [42]:

- ❖ Read, write and delete SMS messages.
- ❖ Send SMS messages.
- ❖ Monitor the signal strength.
- ❖ Monitor the charging status and charge level of the battery.
- ❖ Read, write and search phone book entries.

6.3.3 Applications of GSM module or GPRS module

They can feature all the functionalities of a mobile phone through computer like making and receiving calls, SMS, MMS etc. These are mainly employed for computer based SMS and MMS services.

The GSM/GPRS module demonstrates the use of AT commands. They can feature all the functionalities of a mobile phone through computer like making and receiving calls, SMS, MMS etc. These are mainly employed for computer-based SMS and MMS services [42].

6.3.4 SIM900 GSM/GPRS shield

The SIM900 GSM/GPRS shield is a GSM modem that can be used in a variety of IoT projects. You can use this shield to do practically whatever a regular cell phone can, including sending and receiving SMS text messages, making and receiving phone calls, and connecting to the internet via GPRS, TCP/IP, and more! To top it off, the shield is compatible with a quad-band GSM/GPRS network, which means it can be used almost everywhere in the world [43].

6.3.4.1 Hardware Overview of SIM900 GSM/GPRS Shield

The SIM900 GSM/GPRS shield is designed to surround the SIM900 chip with everything necessary to interface with Arduino, plus a few extra goodies to take advantage of the chip's unique features [43].

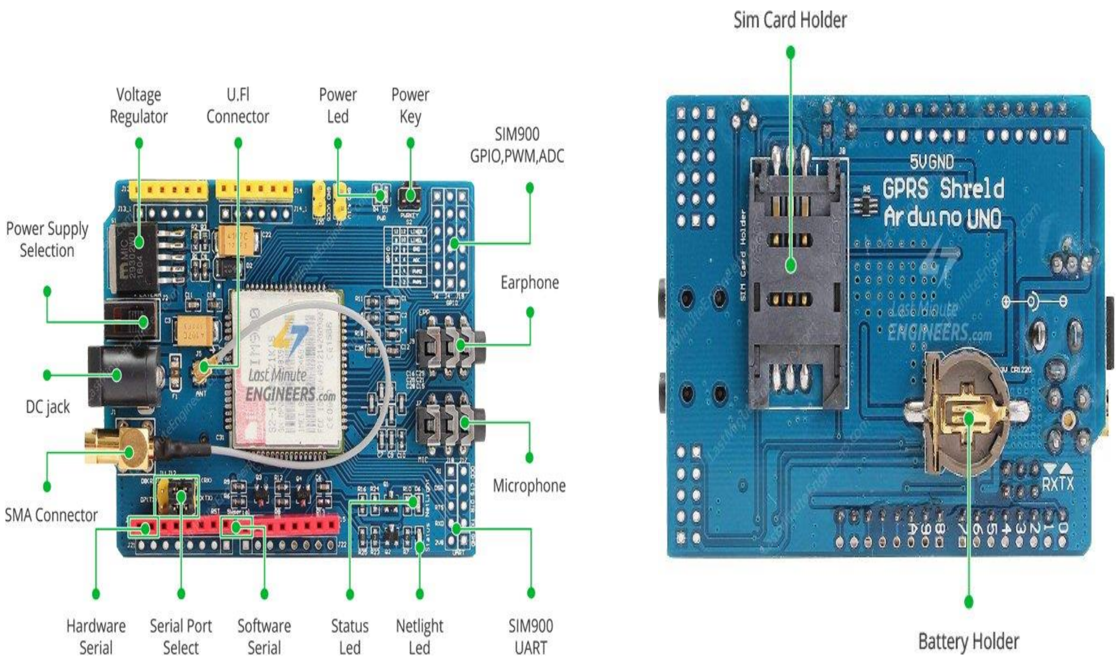


Fig 6.8: SIM 900 GSM/GPRS

6.3.4.1.1 LED Status Indicators

There are three LEDs as shown in fig 6.9 on the SIM900 GSM/GPRS shield which indicates connectivity or power status. By observing these LEDs you can get a visual feedback on what's going on with the shield [43].

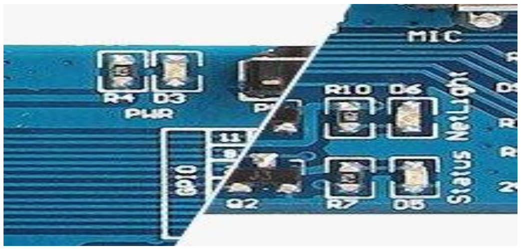


Fig 6.9: LED status indicator

PWR: This LED is connected to the shield's power supply line. If this LED is on, the shield is receiving power.

Status: This LED indicates SIM900's working status. If this LED is on, the chip is in working mode.

Net light: This LED indicates the status of your cellular network. It'll blink at various rates to show what state it's in.

6.3.4.1.2 Supplying Power for SIM900 Shield

One of the most important parts of getting the SIM900 shield working is supplying it with enough power.

The operating voltage of SIM900 chip is from 3.4V to 4.4V. To keep supply voltage shown in fig 6.10 safe at 4.1V, the shield comes with a high current, high accuracy, low-dropout voltage regulator MIC29302WU from Micrel capable of handling load currents up to 3A.

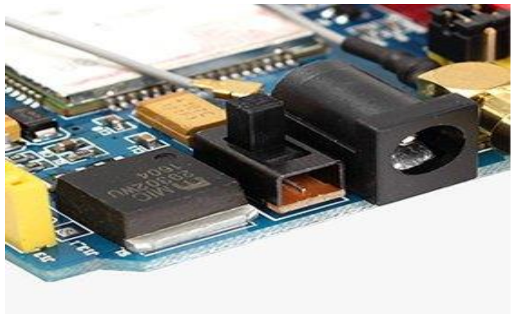


Fig 6.10: Supply voltage

You can add an external power supply to the shield with the 5.5mm DC jack, to which you can connect any 5V-9V DC wall adapter you have [43].

6.3.4.1.3 UART Communication

The SIM900 GSM/GPRS shield uses UART protocol shown in fig 6.11 to communicate with an Arduino. The chip supports baud rate from 1200bps to 115200bps with Auto-Baud detection [43].

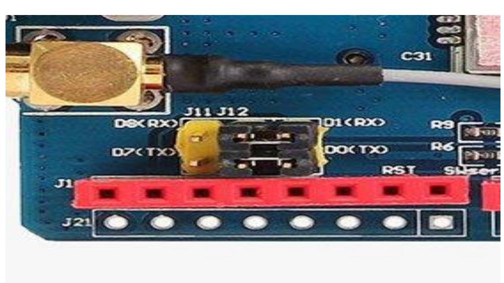
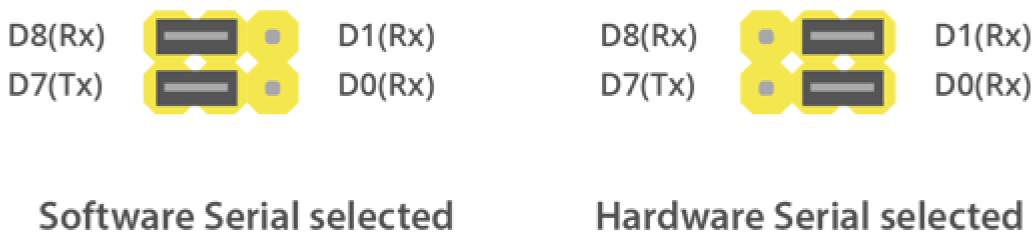


Fig 6.11: UART

With the help of jumpers you can connect (RX,TX) of the shield to either Software Serial(D8,D7) or Hardware Serial(D1,D0) of the Arduino.



6.3.4.1.4 Speaker & Microphone

The shield comes with two standard 3.5mm jacks. One for stereo earphone and other for mono microphone. It allows you to use SIM900’s audio interface to make and receive voice calls and listen FM radio [43].

Fig 6.12: Speaker and microphone

Mic: You can connect an external electret microphone to this jack.

Earphone: You can connect earphones to this jack. Any ‘iPhone’ or ‘Android’ compatible earphones should work.

6.3.4.1.5 Antenna

An antenna shown in fig 6.13 is required to use the SIM900 for any kind of voice or data communications as well as some SIM commands.

Fig 6.13: Antenna

The shield has two interfaces for connecting antenna viz. a U.FL connector and a SMA connector. They are connected through a patch cord.

The shield usually comes with a 3dBi GSM antenna and allows you to put the shield inside a metal case(as long the antenna is outside) [43].

6.3.4.1.6 SIM Socket

There's a SIM socket shown in fig 6.14 on the back. Any activated, 2G full-size SIM card would work perfectly.

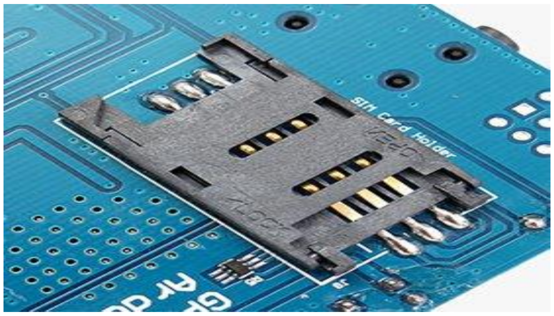


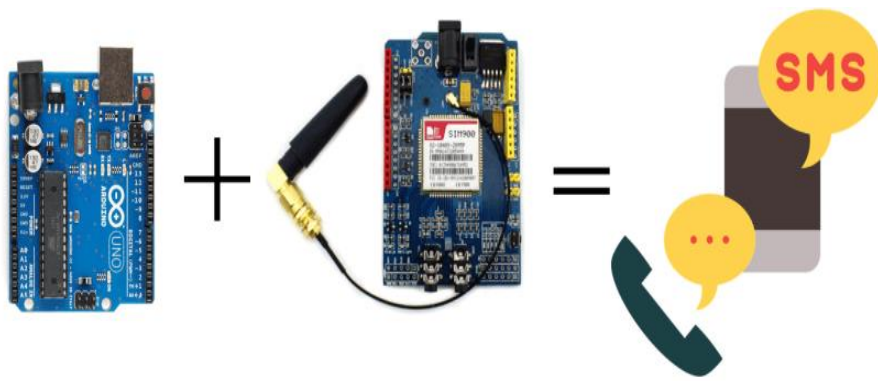
Fig 6.14: Sim socket

The workings of the SIM card socket can take some getting used to. To unlock the latch, push the top part of the assembly, and then lift it up. Place the SIM card into the bottom part of the socket. Then fold the arm back into the body of the socket, and gently push it forward towards the LOCK position [43].

6.3.1.4.7 RTC(Real Time Clock)

The SIM900 shield can be configured to keep time. So there is no need for any separate RTC. This will keep the time even when the power is OFF [43].

6.3.5 Connecting SIM900 GSM/GPRS Shield to Arduino UNO



To start with, connect D7(Tx) and D8(Rx) pin on shield to digital pin#7 and #8 on Arduino. As we'll be using software serial to talk to the shield, make sure the jumper cap is placed on the software serial port select.

Power the shield using external power supply rated 5V 2A. Do not be tempted to connect this pin to 5V supply on Arduino, as the shield may not work due to the lack of supply current. Also make sure you select the external power source with the slide switch next to the DC jack [43].

6.3.5.1 Connecting SIM900 GSM Shield to PC

In order to operate SIM900 GSM Shield directly over PC, you need to connect it to PC using any USB to TTL converter.

Below image shows SIM900 GSM Shield connected to PC through PL2303 USB to TTL converter [43].

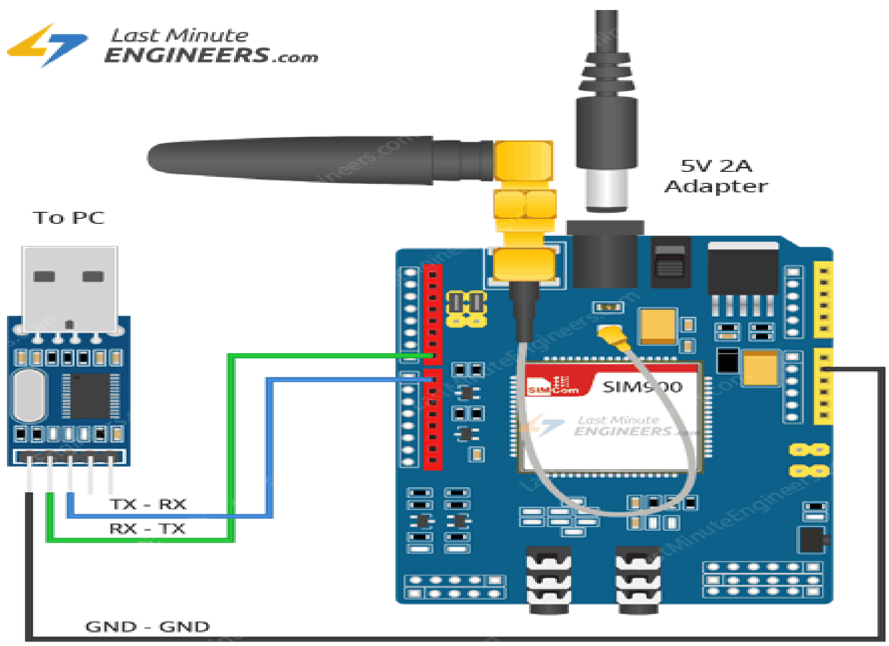


Fig 6.15: Connection of SIM 900 with arduino

6.3.5.2 Powering Up/Down SIM900 Chip

Even if you power the shield up, you need to turn on the SIM900 chip to get it working.

As per datasheet, pulling the **PWRKEY** pin on the chip LOW for at least one second will power up/down the chip. There are two ways to do this with our shield [43].

6.3.5.2.1 Hardware Trigger

Fig 6.16: Hardware trigger

The shield comes with a right angle tactile switch situated near the PWR LED indicator. You need to press that switch for about 2 seconds to power the shield up/down [43].

6.3.5.2.2 Software trigger

Instead of manually pressing the PWRKEY every time, you can turn the SIM900 up/down programmatically [43].

6.4 AT Commands

AT commands are used to control MODEMs. AT is the abbreviation for Attention. These commands come from Hayes commands that were used by the Hayes smart modems. The Hayes commands started with AT to indicate the attention from the MODEM. The dial up and wireless MODEMs (devices that involve machine to machine communication) need

AT commands to interact with a computer. These include the Hayes command set as a subset, along with other extended AT commands[44].

AT commands with a GSM/GPRS MODEM or mobile phone can be used to access following information and services:

- ❖ Information and configuration pertaining to mobile device or MODEM and SIM card.
- ❖ SMS services.
- ❖ MMS services.
- ❖ Fax services.
- ❖ Data and Voice link over mobile network.

6.4.1 Command, Information response and Result Codes

The AT commands are sent by the computer to the MODEM/mobile phone as shown in fig 6.18. The MODEM sends back an Information Response i.e. the information requested by or pertaining to the action initiated by the AT command. This is followed by a Result Code. The result code tells about the successful execution of that command [44].

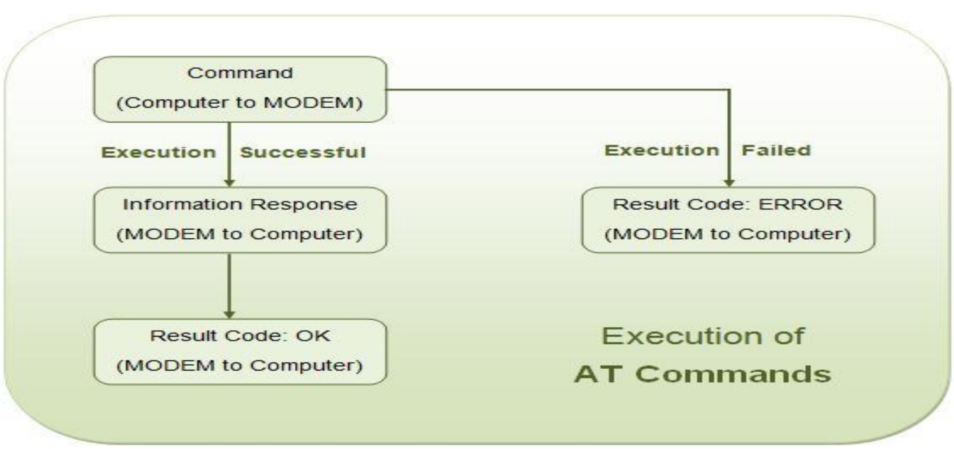


Fig 6.18: Data flow chart showing execution of AT Commands

There are also unsolicited Result Codes that are returned automatically by the MODEM to notify the occurrence of an event. For example the reception of a SMS will force MODEM to return an unsolicited result code [44].

6.4.1.1 AT Commands' Syntax

- **Case Sensitivity**

The AT commands are generally used in uppercase letters. However some MODEMs and mobile phones allow both uppercase and small case letters [44].

- **Single Command**

The AT commands include a **prefix AT** which indicates the beginning of the command to MODEM; and a **carriage return** which indicates the end of the command [44].

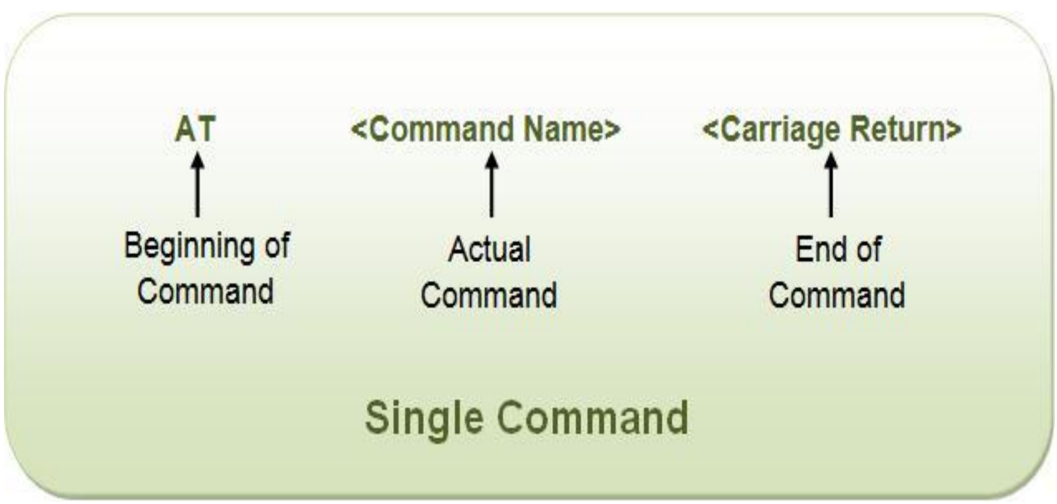


Fig 6.19: Figure Showing Command Format Of Single AT Commands

However string ‘AT’ itself is not the part of the command. For example in ATD, D is the command name not ATD.

The extended AT commands have a ‘+’ in the command name.

For example: **AT+CGMI<Carriage return>**

- ❖ **Command Line**

Multiple AT commands can be sent to MODEM in a single command line. The commands in a line are separated by a semi-colon (;) [44].

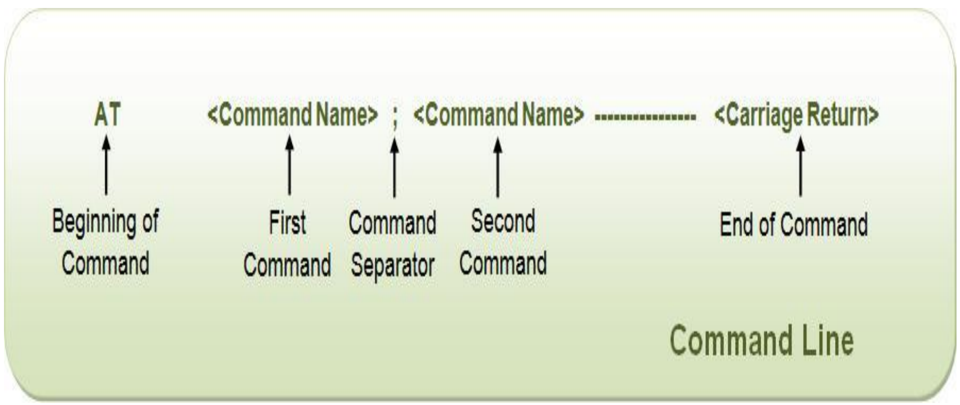


Fig 6.20: Figure Showing Format For Sending Multiple Commands In Single AT

Figure showing Command format of Single AT Commands

For example: **AT+CGMI; +CBS<Carriage return>**

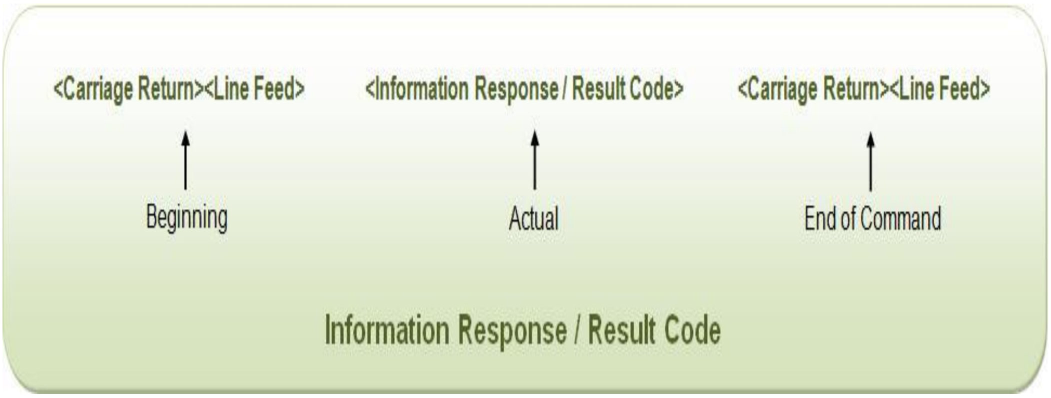
- ❖ **String in Command Line**

Strings in a command line are enclosed in double quotes.

For example: **AT+CGML=”ALL”<Carriage return>**

Information Response and Result Code –

The Information Response and Result Codes, returned by the MODEM, have a carriage return and line feed in the beginning as well as at the end [44].



For example:

<Carriage return><Line feed>OK<Carriage return><Line feed>

<Carriage return><Line feed>ERROR<Carriage return><Line feed>

<Carriage return><Line feed>+CBC: 0, 60<Carriage return><Line feed> etc.

- **Sequence of Execution**

In the command line, the command appearing first is executed first. The execution then follows for second appeared command and so on. The execution of commands in a command line takes place in sequential manner.

If an error occurs in the execution of a command, an error result code is returned by the MODEM and the execution of the command line is terminated irrespective of presence of other commands next in the command line [44].

6.4.1.2 Types of commands[44]

There are four types of AT commands:

- Test commands
- Read commands
- Set commands
- Execution commands

Chapter 7

Project

“Design and Implementation of a smart solar cell Orientation system”

The project was implemented in two steps, the first stage is design of a smart solar cell, this is what was mentioned in the first stage, In the second stage of the project, we chose application.

7.1.1 Aim of the project

Increasing the human need to provide electrical energy was the main element of the direction to provide it by exploiting permanent elements such as the sun to convert solar energy into electrical energy using solar cells to obtaining the highest possible energy by tracking the solar cell of the sun regardless of its direction and measuring the efficiency of the system in terms of the amount of energy actually obtained from the movable system and storing that energy in batteries, this solar system is mainly based on directing the solar cells to a fixed point, so that the selection of that point is based on the best point from which the highest solar energy is expected. Hence, the main goal of the project is to obtain the largest possible energy by developing this solar system by using a 360-degree moving system so that it tracks the sun regardless of its location throughout the day to take advantage of it.

7.1.2 Required hardware components

The main parts of the system required as Arduino UNO, servo motors, light dependent resistors (LDR), solar panel, fixed resistors and jump wires.

7.1.2.1 Arduino UNO

The microcontroller used in the project is Arduino UNO, it is the main brain of the project is used to read signal from the LDR sensor which is translated to movement signal for the servo motor, with Some of its better features are:

1. Its biggest feature is that we connect the motherboard to the computer via USB cable
2. It can be powered by a 9V-12V AC to DC converter and the board is running at 5V voltage all the time
3. The Uno features 14 digital I / O pins and 6 analog I / O ports.
4. Many plugins are designed for Uno. Special devices are available for internet, bluetooth, motor control, etc.
5. It is the cheapest board compared to its features

Figure 7.1: Arduino Uno

Table 7.1: specifications of Arduino Uno

Microcontroller	ATmega328P
Operating voltage	5v
Recommended input voltage	7-12v
Input voltage limits	6-20v
Analog input voltage	6(A0-A5)
Digital I/O pins	14(out of which 6 provide PWM

	output)
DC currents on I/O pins	40Ma
DC currents on 3.3v	50MA
Flash memory	32KB
SRAM	2KB
EEPROM	1KB
Frequency(clock speed)	16MHz

7.1.2.2 Servo motor

Servo is one of the special motor types and it is used in position control, so it is sometimes called control motor and it is a motor that can rotate at a specific angle by preprogramming it via the Arduino or any electronic circuit.

The motor contains a column that can control its position and it is controlled by an electrical signal that determines the amount of shaft movement.

7.1.2.2.1 Servo motor features

- High efficiency
- High output power relative to their size
- More constant torque at higher speed
- High acceleration
- High-speed performance
- Torque control
- Smooth running
- High accuracy
- Small in size

➢ We use two servo motors one for east-west direction and other for north-south direction to follow the sun in 360 degree to get the highest possible energy by tracking the solar cell of the sun, regardless of its direction.

The servomotor used is **FS5115M**

Specifications:

- Dimensions: 40.8 × 20.1 × 38 mm
- Weight: 56 g
- Operating Speed: 0.18sec/60degree (4.8V) or 0.16sec/60degree (6V)
- Stall Torque: 15.5 kg.cm (6V)
- Operating Voltage: 4.8V~6V
- Control System: Analog
- Direction: CCW
- Running degree: 180degree
- Bearing Type: 2 Ball Bearing
- Gear Type: Metal Brush Motor
- Motor Type: Metal
- Connector Wire Length: 30 cm

Figure 7.2: Servo motor FS5115M

7.1.2.3 Light dependent resistor (LDR)

4 light dependent resistors also known as variable resistor which work as sensing device for the tracking system, it`s senses the intensity of light that

falls on it by varying it electric resistance, the resistance decrease with increasing light and increase with decrease in light intensity.

Figure 7.3: LDR

To Know the location of the sun to get the highest solar energy by using four light dependent resistors placed on the sides of the base as shown in fig7.4 previously designed to sense the the highest light by tracking the sun east and west by comparing the values of the resistors in the north and south, and accordingly the base that carries is moved the Solar cells vertically. The amount of light incident on the east and west resistors is also compared, and accordingly the base moved horizontally.

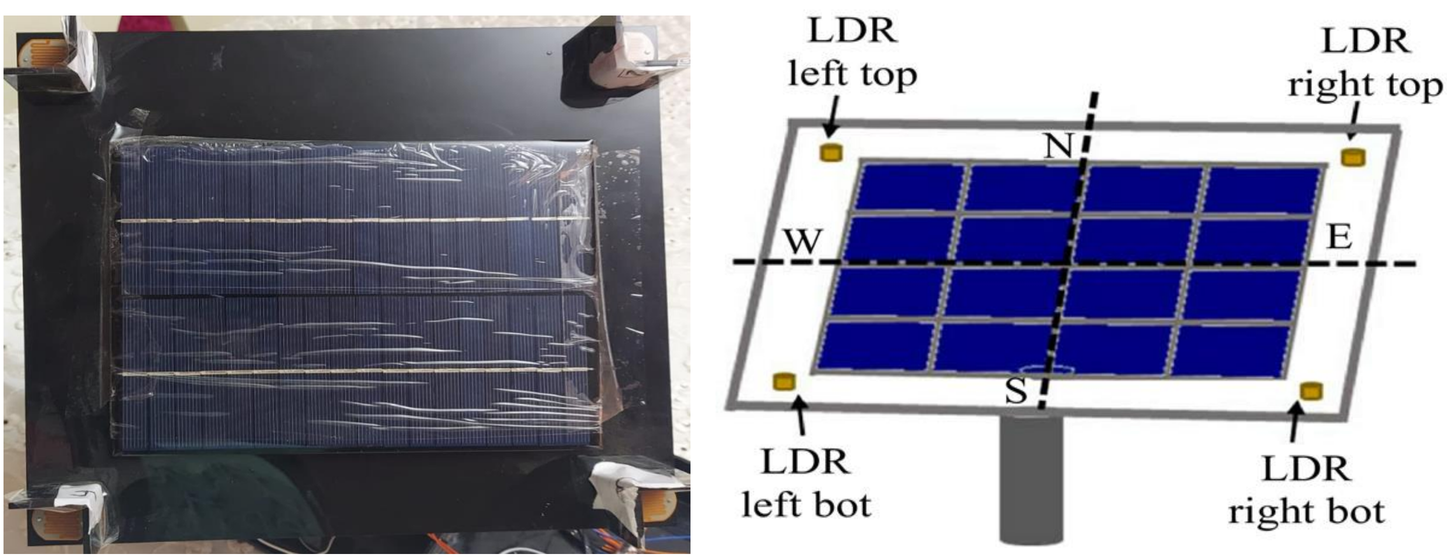


Figure 7.4: Positions of LDR

7.3.3 4 fixed resistors of 10 Kohm:

The light dependent resistors dependent on the value of the fixed resistance in the circuit and it's determines the voltage difference when exposed to light and total cover.

7.1.3.4 Solar panel:

Solar panels is a photovoltaic system absorb sun light as a source of energy to generate electricity, solar energy is the photovoltaic cell which converts light energy received from sun into electrical energy

Figure 7.5: 5.2W 12V Solar panel

7.1.3.5 Wires

Used to connect the component together in the electrical circuit

7.1.3.6 Battery

Using 9Volt battery for feeding

7.1.4 Design and steps of implementation

1. The first stage: (the design stage) as shown in fig7.6, in which the proposed system is designed by designing a body as shown in fig6.7 to carry the solar cells and direct them to the sun throughout the day, so that this base is moved in 360 degrees, has been manufactured using acrylic and cut it using laser machine.

General form

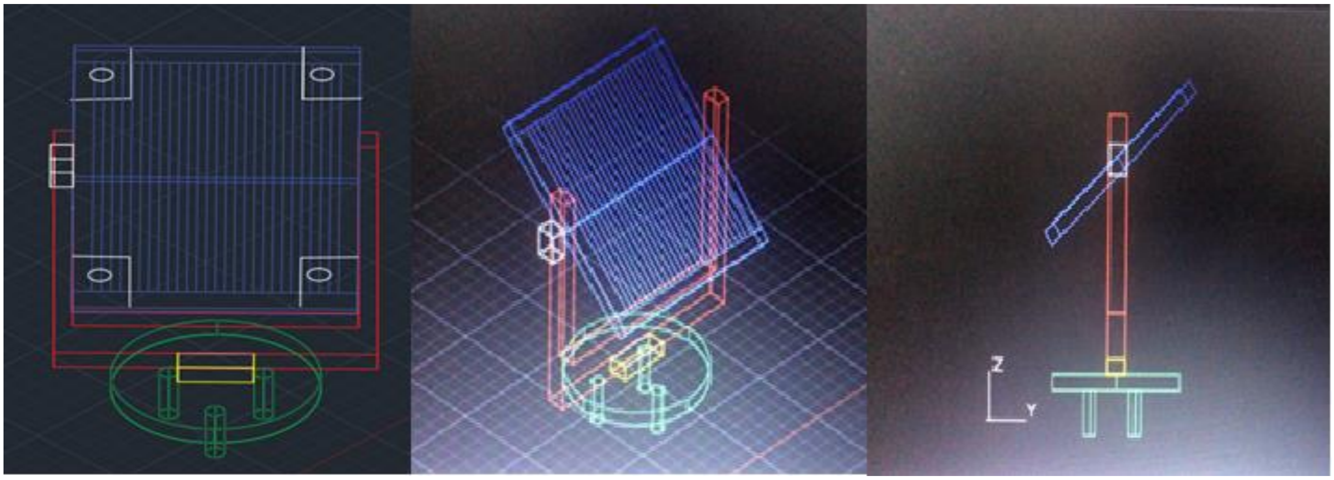


Figure 7.6: General form using Auto cad

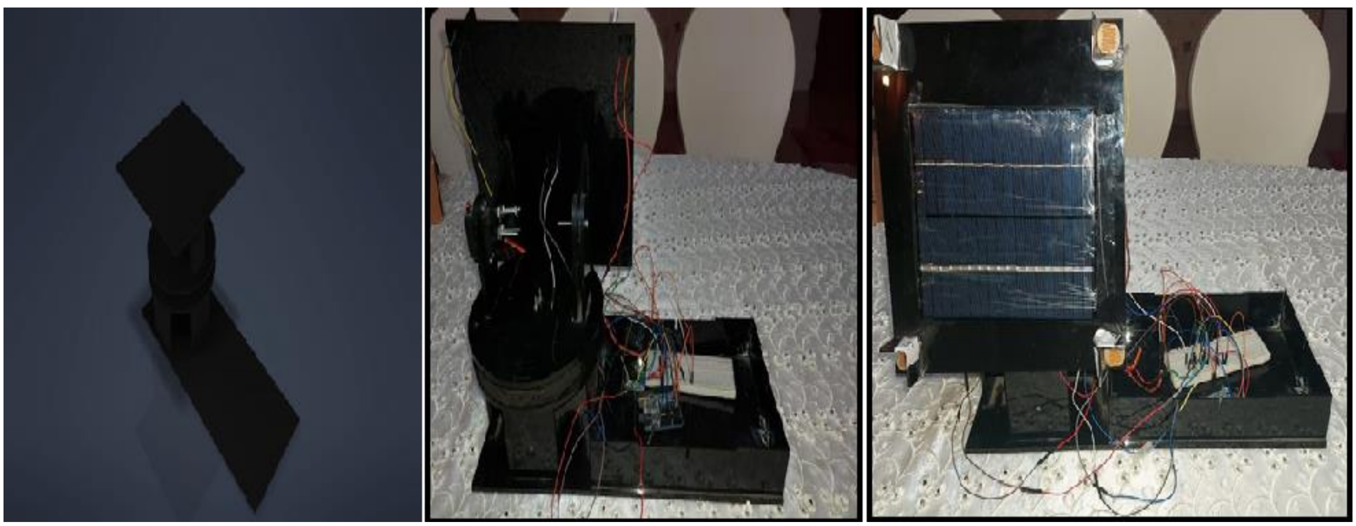


Figure 7.7: Body

2. The second stage: searching for the appropriate motor by determining its type and the torque required to carry both the base and the solar cell, so that one of them is used to allow movement in the vertical direction and the other to allow movement in the horizontal direction.
3. The third stage: Programming the Arduino to be the link between the signals received from the light dependent resistances (LDR) and the motors so that the motors are started based on the processing of the signal received from the LDR resistors by the Arduino.

4. The fourth stage: is the connection and assembly of the system components, taking into account the installation of four light dependent resistors on the sides of the previously designed base.

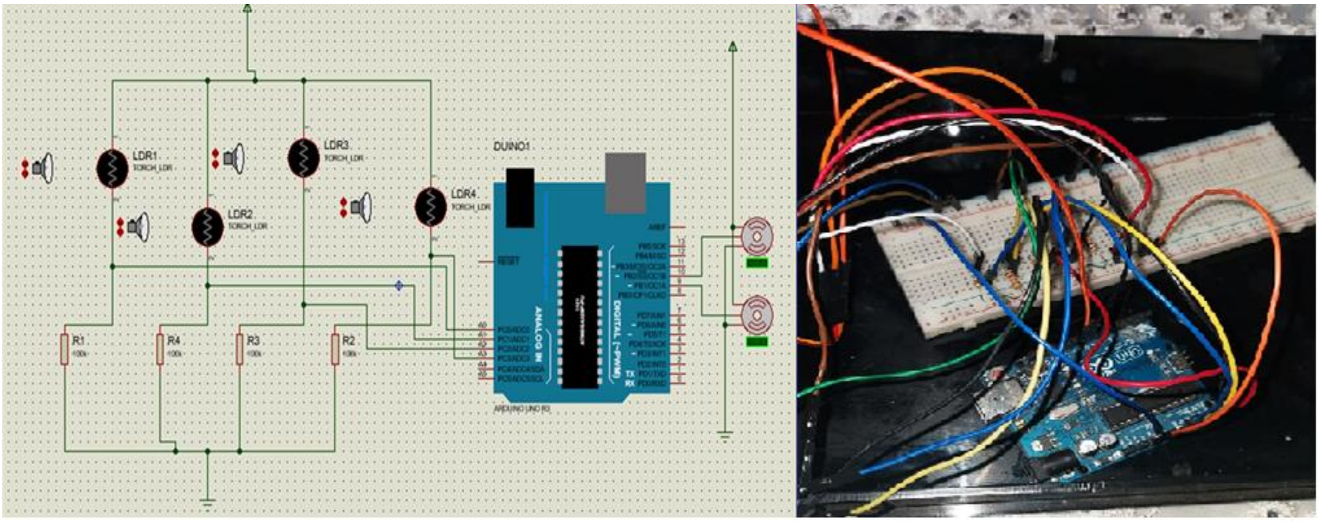


Figure 7.8: circuit diagram

5. Fifth stage: testing the suitable system so that it is placed in an open place to ensure its ability to determine the direction of the sun, test the movement of motors in both horizontal and vertical directions over the daylight hours, record voltage and current readings using voltmeter and Ameter at different times of and knowing problems, if any.
6. The sixth stage: studying the results and working to solve problems.
7. The seventh stage: designing a fixed system, the same type of solar cell used in the movable system and in the same surrounding conditions, and taking readings at the same time times taken for the moving system.
8. The eighth stage: a comparison between the results of the fixed and moving system and the efficiency of the moving system is compared to its fixed counterpart to evaluate it in practice and study the extent of benefit from it and determine Advantages and disadvantages.

9. The ninth stage: Using the recorded readings during the practical implementation to study the advantages of the project and work to improve the defects, take advantage of the project outputs by storing the incoming energy in rechargeable batteries and converting it from a DC to a AC to working the different devices.

   So the comparison and the measurement between fixed solar cell and the movable solar cell shown in Table 7.2

Table 7.2: measurement and comparison between fixed and variable solar cell

Time	Fixed	Movable	Capture photos
10:00 AM	$V_{measurment}$ =20.7V $I_{measurment}$= 0.21A P_c=4.347W eff=83.596%	$V_{measurment}$ =20.7V $I_{measurment}$= 0.23A P_c=4.761W eff=91.557%	
11:30 AM	$V_{measurment}$ =20.9V $I_{measurment}$= 0.24A P_c=5.016W eff=96.462%	$V_{measurment}$ =21 V $I_{measurment}$= 0.24A P_c=5.04W eff=96.923%	
1:00 PM	$V_{measurment}$ =21 V $I_{measurment}$= 0.22A P_c=4.62W eff=88.846%	$V_{measurment}$ =21.1V $I_{measurment}$= 0.23A P_c=4.853W eff=93.327%	

2:30 PM	$V_{measurment}$ =20.7V $I_{measurment}$= 0.2A P_c=4.14W eff=79.615%	$V_{measurment}$ =20.9V $I_{measurment}$= 0.21A P_c=4.389W eff=84.404%	
3:30 PM	$V_{measurment}$ =20.1V $I_{measurment}$= 0.03A P_c=0.603W eff=11.596%	$V_{measurment}$ =20 V $I_{measurment}$= 0.1A P_c=2W eff=38.461%	
4:00 PM	$V_{measurment}$ =18.1V $I_{measurment}$= 0.01A P_c=0.181W eff=3.481%	$V_{measurment}$ =20.4V $I_{measurment}$= 0.03A P_c=0.603W eff=11.596%	

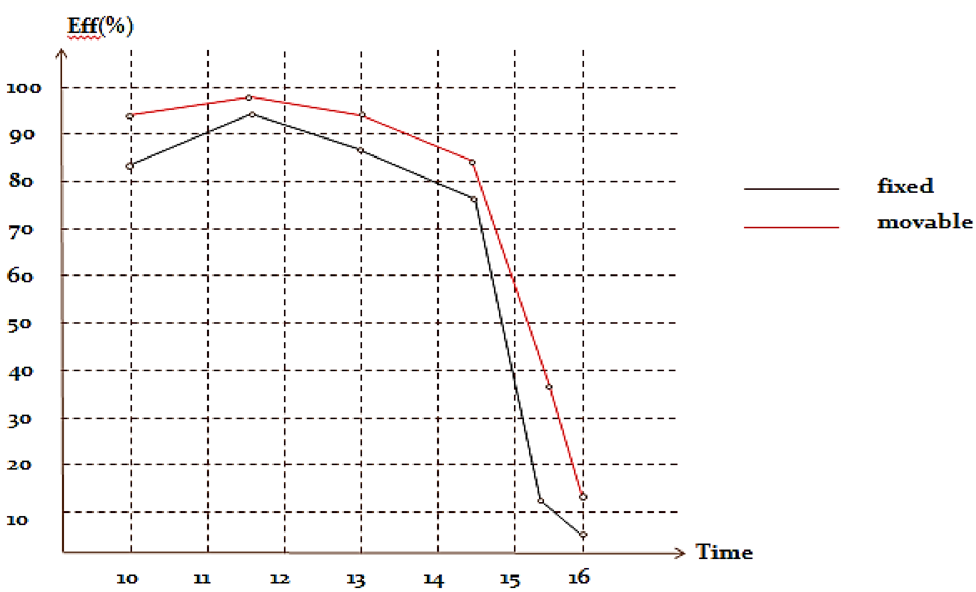


Figure 7.9: graph of comparison between fixed and movable efficiency

The efficiency and the power of the movable solar system greater than the fixed solar system.
At noon time the reading that shown in figure 7.9 are logical, the efficiency in the movable is approximately equal 100 percent and in the fixed solar system close to movable because the sun in this time is perpendicular on the fixed solar system.
From the comparison the movable solar system is better than fixed solar system and take from it high energy.

As we mentioned before in the second stage of the project, we chose application **Smart farm** also known as precision agriculture, smart farming is software-managed and sensor-monitored. Smart farming is growing in importance due to the combination of the expanding global population, the increasing demand for higher crop yield, the need to use natural resources efficiently, the rising use and sophistication of information and communication technology and the increasing need for climate-smart agriculture.

7.2.1 Aim of the project

Smart farming refers to a farm management concept that uses modern technology with the aim of increase the quality and quantity of agricultural products. smart farming has become useful to all farmers – small and large scale, in that it gives farmers access to technologies and devices that help in the maximization of products’ quality and quantity, while reducing the cost of farming.

7.2.2 Required hardware components

7.2.2.1 LM35 temperature sensor

LM35 is a type of commonly used temperature sensor shown as figure 7.10, that can be used to measure temperature with an electrical output comparative to the temperature in (°C).

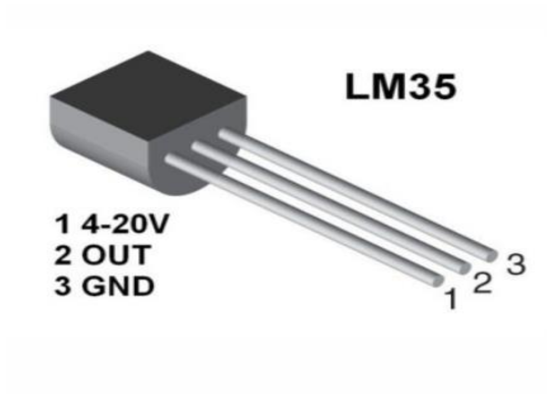


Figure 7.10: LM35 temperature sensor

- **LM35 temperature sensor features**
  - It can measure temperature from -55°C to 150°C.
  - Its Output voltage is directly proportional (Linear) to temperature.
  - Its low-cost temperature sensor.
  - Operates From 4 V to 20 V
  - 0.5°C Ensured Accuracy

7.2.2.2 Water level sensor

A Water Level Indicator is used to detect and indicate the water level in an overhead tank or any other water container. Water Level Sensor Pinout shown in figure 7.11

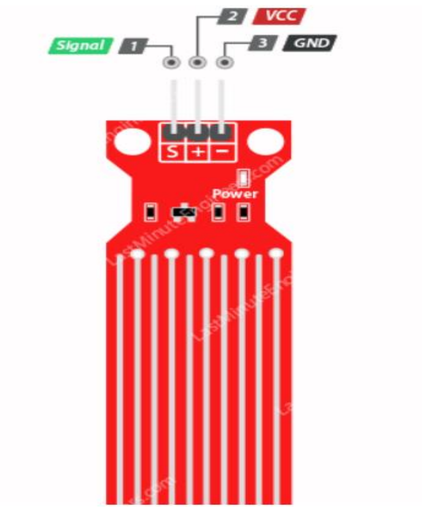


Figure 7.11: Water level sensor

➢ Specifications

- Working Voltage: DC 3-5V
- Working Current: <20mA
- Detection Area: 40 mm x 16 mm
- Fixed Hole Size: 3.2 mm
- Size: 65 mm x 20 mm x 8 mm

7.2.2.3 Moisture soil sensor

The moisture sensor consists of two probes that are used to detect the moisture of the soil shown as figure 7.12. The moisture sensor probes are coated with immersion gold that protects Nickel from oxidation. These two probes are used to pass the current through the soil and then the sensor reads the resistance to get the moisture values.

Figure 7.12: Moisture soil sensor

➢ Moisture Sensor Module Features & Specifications

- Easy to use with Microcontrollers
- Small, cheap and easily available
- Input Voltage 3.3-5V
- Output Voltage 0-4.2V
- Input Current 35mA

7.2.2.4 GSM module

GSM is a cellular communication module Shown in figure7.13. It stands for global system for mobile communication. Here the GSM Module is used to send SMS alerts told the water is low and also helps the user to manually over ride the system.

Figure 7.13: GSM SIM900 Module

The SIM900 shield packs a surprising amount of features into its little frame. Some of them are listed below:

- Supports Quad-band: GSM850, EGSM900, DCS1800 and PCS1900
- Connect onto any global GSM network with any 2G SIM
- Make and receive voice calls using an external earphone & electret microphone
- Send and receive SMS messages

- Scan and receive FM radio broadcasts
- Serial-based AT Command Set
- Accepts Full-size SIM Card

7.2.2.5 Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.

Figure7.14 Relay

7.2.2.5.1 Specification:

- Maximum load: AC 250V/10A, DC 30V/10A
- Trigger current: 15mA
- Working voltage: 5V
- Module size: 50 x 26 x 18.5mm (L x W x H)
- Four mounting bolts holes, diameter 3.1mm

7.2.2.5.2 Module interface:

- DC+: positive power supply (VCC) 5Vdc
- DC-: negative power supply (GND)

- IN: can be high or low level control relay

7.2.2.5.3 Relay outputs:

- NO: normally open relay interface
- COM: Common Interface Relays
- NC: normally closed relay interface

7.2.2.6 Water pump

Pumps are used to move liquids shown in figure 7.12. Mechanical energy is converted into hydraulic energy by pumps.

The pump works through the Arduino. I have the command of the pump and the pump a Dc motor. It works, because the moisture sensor that inside soil, it send to Arduino that the percentage that I got it is low so the Arduino tell to pump to work. If the percentage is high so Arduino tell to pump to stop .

Figure 7.12 Water pump

Features of water pump :

- Pump Size: 90 mm * 40 mm * 35 mm
- Weight: 106g
- Working voltage: DC12V
- Working current: 0.5-0.7A
- Empty load current: 0.18A
- Lift : Vertical up to 3 meters

- Life: up to 2500H,
- Water temperature: up to 80 degrees
- Outlet diameter: diameter 6 mm, an outer diameter of 9 mm
- When Voltage 6V : power is 6W / H

7.2.2.7 Fan

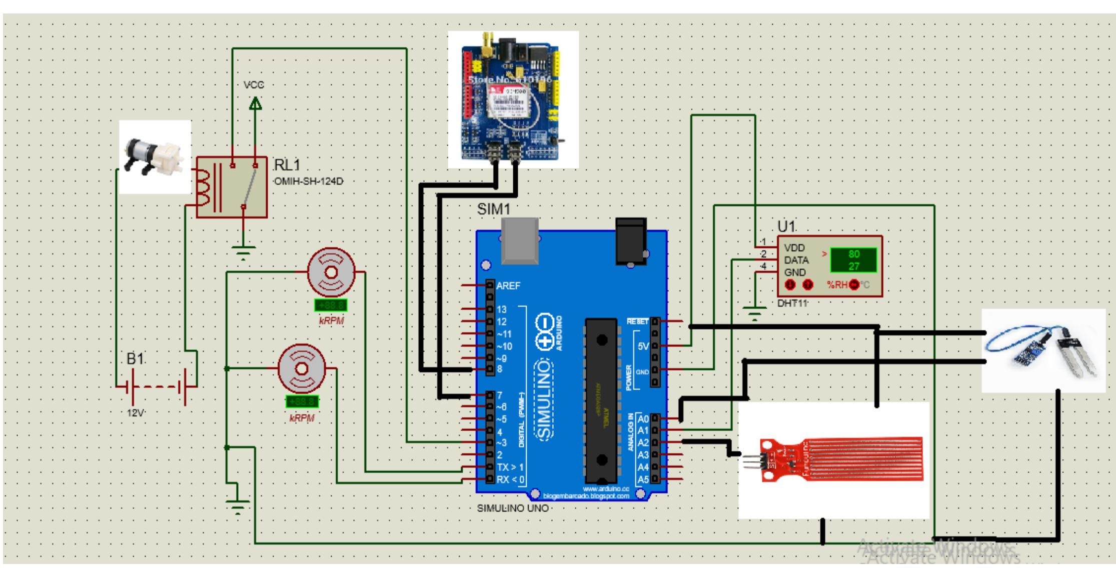
Fan works when the temperature is more than a certain degree that you have set in our system, Arduino set command to fan to work .

Figure 7.13 fan

Specification:

- DC Brushless Fan 5Vdc
- Current: 170 mA
- Size 5x5x1 Cm3
- Long Connecting Wire

7.2.3 Working of smart farm



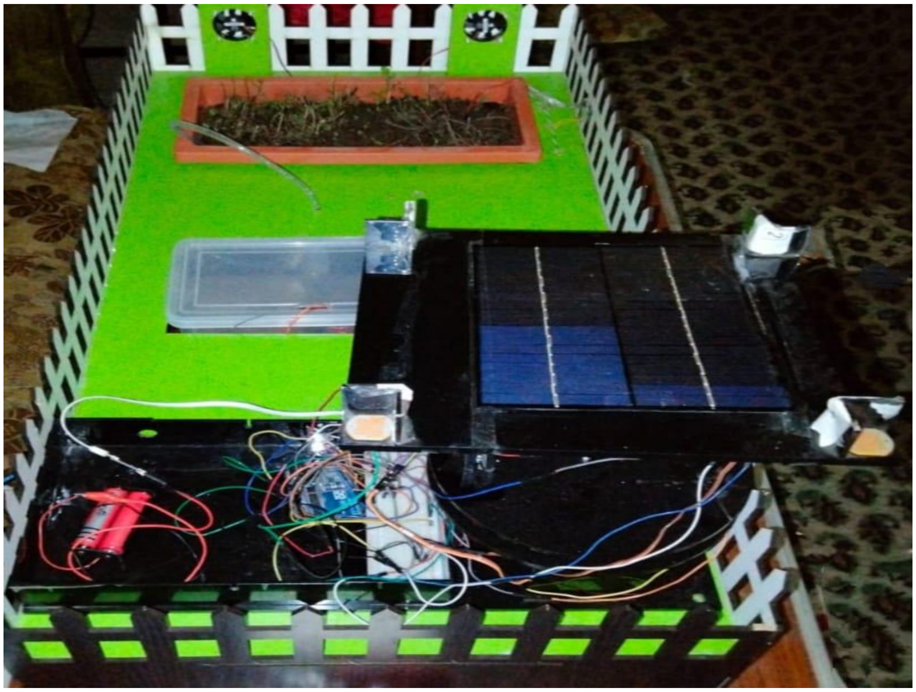


Figure 7.15: smart farm system

I have a battery that powers the Arduino system and the GSM and other

1. Tank has a water level sensor alerts me about the water level in the tank because if the water decrease it will send me a message telling me to decrease water
2. in the pump, there is a hose for taking out the water from the tank, and the second hose goes to the planting and works through the arduino which sends an order to the pump
3. the pump works when the arduino gives it a start command because the soil has a Soil moisture sensor content if less than the specified percentage, it sends me a signal to water the soil until it reaches the required percentage and comes back to stand again as shown as figure7.16

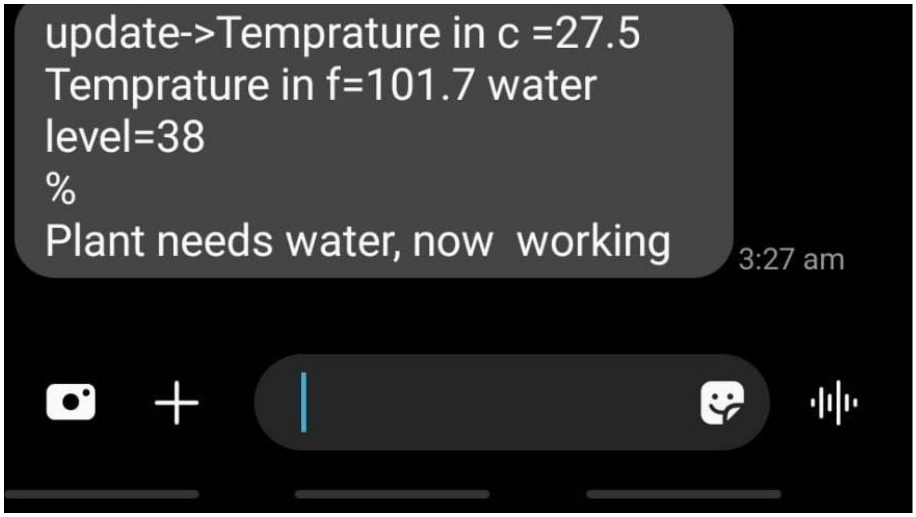
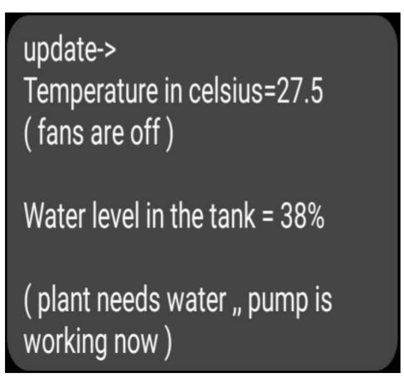


Figure 7.16: message on mobile

4. Soil moisture sensor connected to the soil and looks at the arduino. if the ratio is less than the specified number, the arduino give a command to the pump that it drops water and we put a temperature sensor, **what it is function?**

It senses the heat of the plant, and if the temperature increases, it sends a signal to the arduino which sends a command to the fan that it is working. In order to connect the pump, i took the output from the relay on the pump, the relay is between arduino and pump.

Table 7.3 stages of cultivation

Date	Message	Capture photos
26/5 8:00 AM		

29/5 9:00 AM	update-> Temperature in celsius=33 (fans are on) Water level in the tank = 14% (please refill the tank) (plant needs water ,, pump is working now)	
1/6 10:00 AM	update-> Temperature in celsius=30 (fans are off) Water level in the tank = 32% (plant needs water ,, pump is working now)	
4/6 12:00 AM	update-> Temperature in celsius=21 (fans are off) Water level in the tank = 74% (plant doesn't need water ,, pump is off now)	

7.2.4 Problems and related solutions:

➢ **<u>First problem:</u>**

We have purchased servo motor with plastic core, Theoretically, the torque of this motor is 4.5Kg and moves 180 degree.

Even through the vertical part is 600g, the torque of this servo motor is not what it was written and cannot carry 4.5Kg.

Solution: we have purchased another servo motor **FS5115M** with iron core and with torque 15.5Kg.

- **Second problem:**

  We have purchased four small size LDRs when we compare between them we found variation big variation.

  Also when we purchased the medium size of LDRs we found variation between them.

Solution: we have purchased the biggest size LDRs with the highest sensitivity

- **Third problem:**

  The weather are clouds the intensity of light is the same then the sensor cannot sense.

- **forth problem:**

  - vibration

  The panel was not fixed perpendicular to the sun, but was moving in a small range in a vibrational form between the perpendicular angle to the sun.

  Solution: It was resolved in the code.

- **Fifth problem:** The batteries are used up in less time than the batteries are charged

Solution: We need to work with large system with a bigger solar cell, and high efficiency.

Chapter 8

Conclusion and future work

8.1 Conclusion

As solar energy is considered one of the main sources of energy in the near future, In this document , we give a simple and concise overview of the solar tracking mechanism to improve the solar gain energy, also the costs of the solar tracker operation and cost maintenance is relatively low [8] This document explains solar tracking system through the use of Arduino controller, which also shows the solution software appropriate for increasing the yield of solar systems to the greatest value through the system guide to solar radiation great point, As a result of the lack of efficiency of electricity generation from fixed solar cells. After studied this work we have got the maximum energy from the sun and make the system eco-friendly with the environment. The maximum energy from the sun obtained by move the panel in correct direction with correct angle and makes the panel perpendicular to the sun. The effectiveness of the Sun tracker is confirmed experimentally. And the output has been plotted into a graph and has been analyzed. The results showed that the dual-axis solar tracking system is highly efficient in terms of electrical energy output when compared with fixed solar system, The ability to conserve the natural resources and use it with a solar panel, so that the entire system is eco-friendly, the smart farming will revolutionized the world of farming and it will increase the productivity as well as improve the quality and can save lives of farmer. There is an urgent need for a system that makes the agricultural process easier and burden free from the farmer’s side. as well as giving a splendid boost to the production of the crops to save farmer’s effort, water and time has been the most important consideration

8.2 Future work

We will work on remote sensing so that the tank fills automatic.

We will make a link so that the tank fills automatic without sending a message that the water has run out or will run out.

Appendix

```
#include <Servo.h>
Servo  myservoh;
int servohlimH=180;
int servohlimL1=0;
int servoh=0;
Servo myservv;
int servoVlimH=180;
int servoVlimL1=70;
int servov=0;
int prob1,prob2,prob3,prob4;
int sensorValue0,sensorValue1,sensorValue2,sensorValue3;
float threshold=0.3;
void setup() {
  // put your setup code here, to run once:
myservv.attach(9);
myservv.write(servoVlimL1);
delay(1000);
 myservoh.attach(10);
 myservoh.write(servohlimL1);
 delay(1000);
 Serial.begin(9600);
 pinMode(A0,INPUT);
 pinMode(A1,INPUT);
 pinMode(A2,INPUT);
```

```
 pinMode(A3,INPUT);
}
void loop() {
servov=myservv.read();
servoh=myservoh.read();
sensorValue0 = analogRead(A0);
 sensorValue1 = analogRead(A1);
 sensorValue2 = analogRead(A2);
 sensorValue3 = analogRead(A3);
 prob1=(sensorValue0+sensorValue1);
 prob2=(sensorValue2+sensorValue3);
 prob3=(sensorValue0+sensorValue3);
 prob4=(sensorValue1+sensorValue2);
 myservv.write(servov+1);
 delay(20);
 if(servov > 180){
 servov= servoVlimH;
  myservv.write(servov);
  delay(10);
 }
   }
     else if(prob1 < (prob2+threshold)){
 myservv.write(servov-1);
 delay(10);
 if(servov < 70){
```

```
myservv.write(servov);
  delay(10);
 }
}
  if((prob3+threshold) > prob4)
  {
    myservoh.write(servoh+1);
 delay(20);
 if(servoh > 180){
  delay(10);
 }
    }
    else if(prob3 < (prob4+threshold))
  {
    myservoh.write(servoh-1);
 delay(10);
 if(servoh < 0){
  delay(10);
 }
    }
}
```

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