IOT BASED AUTOMATED SOLAR PANEL CLEANING AND MONITORING TECHNIQUE

A main project report submitted in partial fulfillment of the requirement for the Award of degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

Submitted by

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NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS)

(Accredited ‘A+’ Grade by NAAC, NBA & ISO 9001:2015 Certified institution)

(Approved by AICTE, New Delhi &Permanent Affiliated to JNTUK Kakinada)

NARASARAOPET-522601(A.P)

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CERTIFICATE

This is to certify that the main project entitled" **IOT BASED AUTOMATED SOLAR PANEL CLEANING AND MONITORING TECHNIQUE"** is a bonafide work done by **M. VENKATESWARA RAO (20471A0221), G. MAHENDRA (20471A0212), N. NAGARJUNA (20471A0228), D. NAGARJUNA REDDY (20471A0233),** under our supervision and guidance in partial fulfillment of requirements for the award of degree of **BACHELOR OF TECHNOLOGY** in **ELECTRICAL AND ELECTRONICS ENGINEERING** from JNTUK, Andhra Pradesh, during the year 2023 - 2024.

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ABSTRACT

This project presents an integrated system for interfacing an Arduino with two Light Dependent Resistor (LDR) sensors, a motor driver, a motor, a servo motor, an LCD, a DHT11 temperature and humidity sensor, Node MCU and a voltage and to optimize solar panel performance. This system aims to efficiently adjust the position of the solar panel for maximum sunlight exposure and offer automatic cleaning functionality to remove dust for enhanced efficiency.

The system begins by utilizing the two LDR sensors to monitor ambient light levels. When both sensors detect darkness, indicative of night time, the solar panel remains in a standby position to preserve power. Conversely, if either LDR sensor detects light during the daytime, the Arduino activates the solar panel tracking mechanism using the motor driver and motor.

The voltage and current sensor are employed to continuously measure the output of the solar panel, ensuring optimal energy generation. The collected data is displayed on the LCD, allowing users to monitor the solar panel's performance. Moreover, the system features a servo motor equipped with a dusting mechanism to clean the solar panel surface. When the voltage output falls below a predefined threshold, suggesting a decrease in energy generation possibly due to dust accumulation, the Arduino activates the servo motor to initiate the cleaning process. This automated cleaning action ensures the solar panel operates at its maximum efficiency by maintaining a clear and dust-free surface. Additionally, a Node MCU is placed in the system which helps to upload the sensor data to remote server for efficient monitoring and data analysis.

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CHAPTER- I

INTRODUCTION

1.INTRODUCTION

Now-a-days the technology changes continuously, as of now the people were of using the equipment’s instantly to reduce the time and efficiency .as we know that the electronic device was of changes the man life as well.one of the device is of Generator. It was used in day-to-day life to run the electronic devices for long extension of electronic devices and not to waste of human resources. As we all know that generators are electronic energy storing device and transmitting of energy.

In the recent times, as the world is moving towards 4.0 INDUSTRY REVOLUTION automation has become a vital pillar of industries. Industry 4.0 focus on creating smart environment in manufacturing process, itis a cyber physical system where machine communicates with machine. In solar power generation plants, lakhs of solar panels are arranged in form of multiple arrays. The solar panel farms are generally situated in dirt and dust areas which is mostly in case of tropical countries. The performance of solar panels depends on various factors, the power generated by farms can decrease if there is dust and dirt on panels and this is the main factor for reduction. Solar power plants Node MCU is a microcontroller with WIFI module in built in it. need to be monitored for optimum power output. This helps help us to bringing back efficient power output from power plants while monitoring for faulty solar panels connections, and dust accumulated on panels lowering output and other such issues affecting solar performance. So here we present an automated IOT based solar power monitoring system that allows for automated solar power monitoring from anywhere across the globe over the internet. We use nodemcu controller-based system to monitor solar panel parameters. This solar power monitor system continuous monitors the solar panel and transmits the power output to IOT system over the internet

An embedded system is one kind of a computer system mainly designed to perform several tasks like to access, process, and store and also control the data in various electronics-based systems. Embedded systems are a combination of hardware and software where software is usually known as firmware that is embedded into the hardware. One of its most important characteristics of these systems is, it gives the o/p within the time limits.

1.1 Objectives of the Project

The objective of this research work is to design and develop an IoT-based automated solar panel cleaning and real-time monitoring system using a microcontroller to improve the output and efficiency of a solar module at a low cost.

1.2 Literature Review

- One study by **Zhou** et al. proposed an AI-based solar panel cleaning system that uses machine learning algorithms to detect the level of soiling on the panels and optimize the cleaning process accordingly. The study showed that the proposed system was more efficient and cost-effective than traditional cleaning methods.
- Another study by **Tewari** et al. proposed an IoT-based solar panel monitoring and cleaning system that uses a combination of sensors, actuators, and machine learning algorithms to detect and address issues in real time. The study showed that the proposed system was effective in improving energy yield and reducing maintenance costs.
- A study by **Bhat** et al. proposed a solar panel cleaning and monitoring system that uses drone technology to clean and inspect the panels. The study showed that the proposed system was effective in reducing cleaning time and improving the accuracy of inspection.

CHAPTER-II

SYSTEM DESCRIPTION

2.1 INTRODUCTION

2.1.1 Embedded System Hardware

As with any electronic system, an embedded system requires a hardware platform on which it performs the operation. Embedded system hardware is built with a microprocessor or microcontroller. The embedded system hardware has elements like input output (I/O) interfaces, user interface, memory and the display. Usually, an embedded system consists of:

- Power Supply
- Processor
- Memory
- Timers
- Serial communication ports
- Output/Output circuits
- System application specific circuits

Embedded systems use different processors for its desired operation. Some of the processors used are

1. Microprocessor
2. Microcontroller
3. Digital signal processor

Microprocessor vs. Microcontroller

Microprocessor

- **CPU** on a chip.
- We can attach required amount of ROM, RAM and I/O ports.
- Expensive due to external peripherals.
- Large in size
- general-purpose

Microcontroller

- **Computer** on a chip
- fixed amount of on-chip ROM, RAM, I/O ports
- Low cost.
- Compact in size.
- Specific –purpose

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2.2 EMBEEDED SYSTEM BLOCK DIAGRAM

Embedded system includes mainly two sections, they are

1. Hardware
2. Software

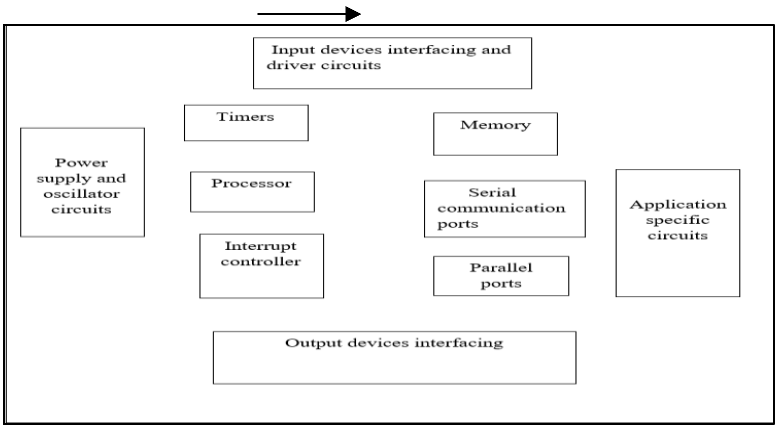

Fig.2.2: Block Diagram

Embedded System Software:

The embedded system software is written to perform a specific function. It is typically written in a high-level format and then compiled down to provide code that can be lodged within a non-volatile memory within the hardware. An embedded system software is designed to keep in view of the three limits:

- Availability of system memory
- Availability of processor's speed
- When the system runs continuously, there is a need to limit power dissipation for events like stop, run and wake up.

Bringing software and hardware together for embedded system:

To make software to work with embedded systems we need to bring software and hardware together. for this purpose, we need to burn our source code into microprocessor or microcontroller which is a hardware component and which takes care of all operations to be done by embedded system according to our code.

Generally, we write source codes for embedded systems in assembly language, but the processors run only executable files. The process of converting the source code representation of your embedded software into an executable binary image involves three distinct steps:

1. Each of the source files must be compiled or assembled into an object file.
2. Physical memory addresses must be assigned to the relative offsets within the re-locatable program in a process called relocation.
3. The result of the final step is a file containing an executable binary image that is ready to run on the embedded system.

Applications:

Embedded systems have different applications. A few Applications of Embedded Systems are smart cards, telecommunications, satellites, missiles, digital consumer electronics, computer networking, etc.

Embedded Systems in Automobiles.

- Motor Control System
- Engine or Body Safety
- Robotics in Assembly Line
- Mobile and E-Com Access

Embedded systems in Telecommunications

- Mobile computing
- Networking
- Wireless Communication

Embedded Systems in Smart Cards

- Banking
- Telephone
- Security Systems

Implementation flow

Stage 1

Considering the problems of existing methods and giving solution to that problem by considering the basic requirements for our proposed system

Stage 2

Considering the hardware requirement for the proposed system

For this we need to select the below components:

1. Microcontroller
2. Inputs for the proposed system (ex: sensors, drivers etc.,)
3. Outputs (ex: relays, loads)

Stage 3

After considering hardware requirements, now we need to check out the software requirements. Based on the microcontroller we select there exists different software for coding, compiling, debugging. we need to write source code for that proposed system based on our requirements and compile, debug the code in that software.

After completing all the requirements of software and hardware we need to bring both together to work our system. For this we need to burn our source code into microcontroller, after burning our source code to microcontroller then connect all input and output modules as per our requirement

2.2.1 POWER SUPPLY

The 230V line voltage is step-down, rectified, filtered and regulated using regulators to obtain desired voltages. This circuit can give +5V output at about 150 mA current and +3.8v and 12v respectively.

2.2.2 TIMERS

A timer in electronics is a device that counts down from a specified time interval and used to generate a time delay.

2.2.3 PROCESSOR

A processor is an integrated electronic circuit that performs the calculations that run a computer. A processor performs arithmetical, logical, input/output (I/O) and other basic instructions that are passed from an operating system (OS). Most other processes are dependent on the operations of a processor.

2.2.4 SERIAL & PARALLEL PORTS

A serial port is a communication interface through which data is transmitted and received sequentially, one bit at a time, over a single communication channel. It's a common method for connecting peripherals, such as modems, mice, keyboards, printers, and various other devices, to a computer or microcontroller.

A parallel port is a type of interface found on computers and other devices that allows for parallel communication, meaning multiple bits of data are transmitted simultaneously over multiple wires. It was commonly used for connecting peripherals such as printers, scanners, and external storage devices to a computer.

CHAPTER- III

HARDWARE DESCRIPTION

3.1 POWER SUPPLY

A power supply is a component that provides at least one electrical charge with power. It typically converts one type of electrical power to another, but it can also convert a different Energy form in electrical energy, such as solar, mechanical, or chemical. A power supply provides electrical power to components. Usually, the term refers to devices built into the powered component. Computer power supplies, for example, convert AC current to DC current and are generally located along with at least one fan at the back of the computer case.

Most computer power supplies also have an input voltage switch that, depending on the geographic location, can be set to 110v/115v or 220v/240v. Due to the different power voltages supplied by power outlets in different countries, this switch position is crucial.

A power supply is an electrical device that supplies electric power to an electrical load. The main purpose of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are separate standalone pieces of equipment, while others are built into the load appliances that they power.

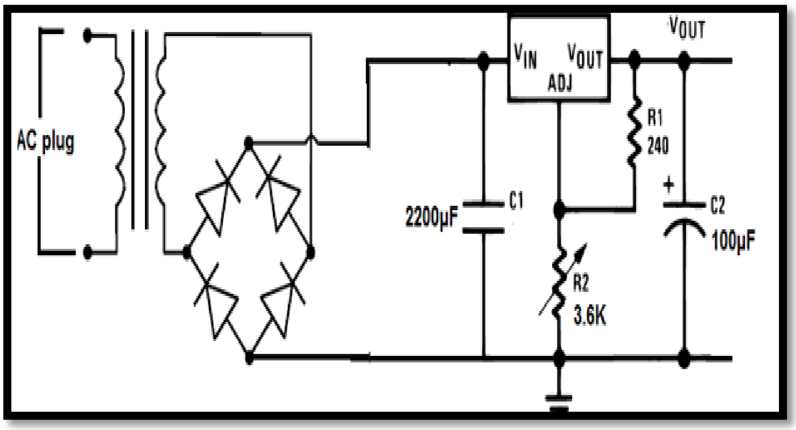

Fig.3.1: Power supply Circuit Diagram

3.2 RECTIFIER

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification, since it "straightens" the direction of current. Rectifiers have many uses, but are often found to serve as components of DC power supplies and direct power transmission systems with high voltage. Rectification can be used in roles other than direct current generation for use as a power source**.**

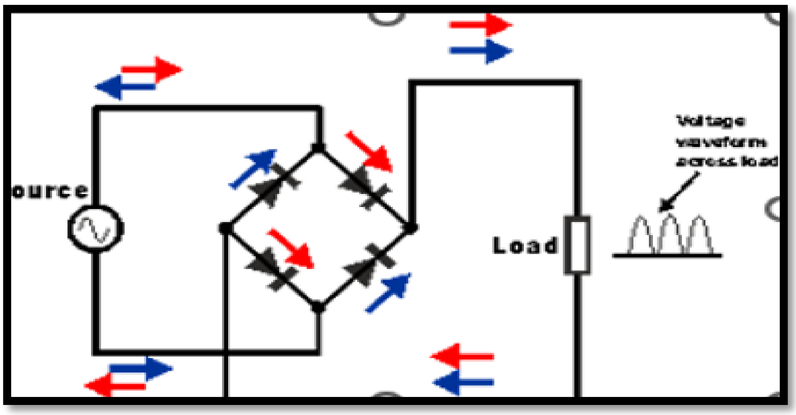

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Fig.3.2: Circuit Diagram of Rectifier

3.3 CAPACITOR

Capacitors are used to attain from the connector the immaculate and smoothest DC voltage in which the rectifier is used to obtain throbbing DC voltage which is used as part of the light of the present identity. Capacitors are used to acquire square DC from the current AC experience of the current channels so that they can be used as a touch of parallel yield.

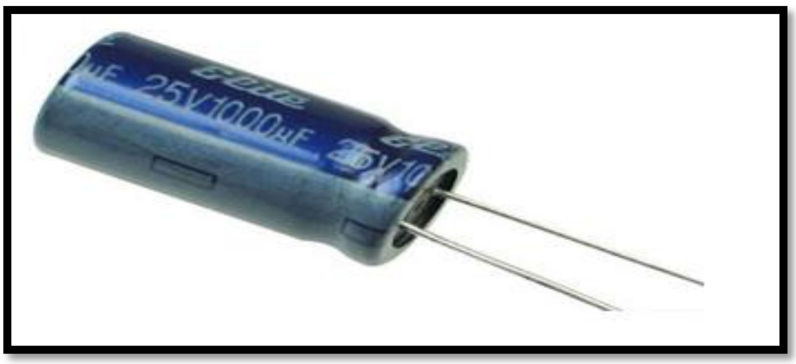

Fig.3.3: Capacitor

3.4. VOLTAGE REGULATOR

The 78XX voltage controller is mainly used for voltage controllers as a whole. The XX speaks to the voltage delivered to the specific gadget by the voltage controller as the yield. 7805 will supply and control 5v yield voltage and 12v yield voltage will be created by 7812.

The voltage controllers are that their yield voltage as information requires no less than 2 volts. For example, 7805 as sources of information will require no less than 7V, and 7812, no less than 14 volts. This voltage is called Dropout Voltage, which should be given to voltage controllers.

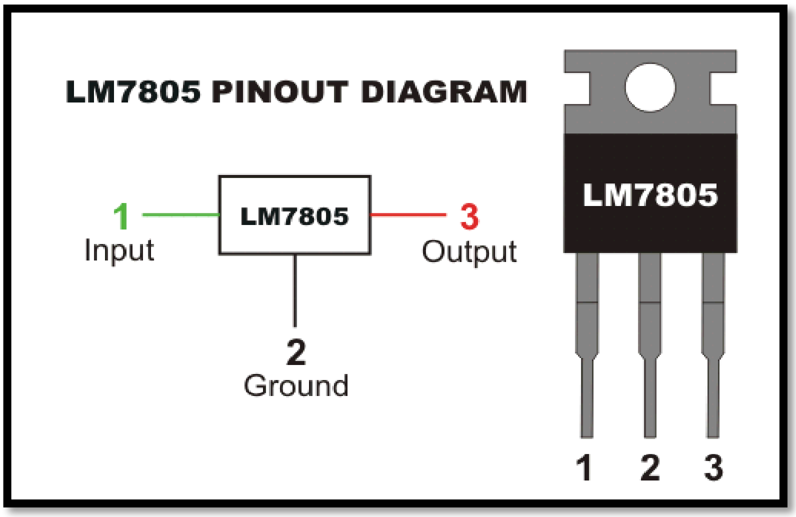

Fig.3.4.1: 7805 voltage regulator with pinout

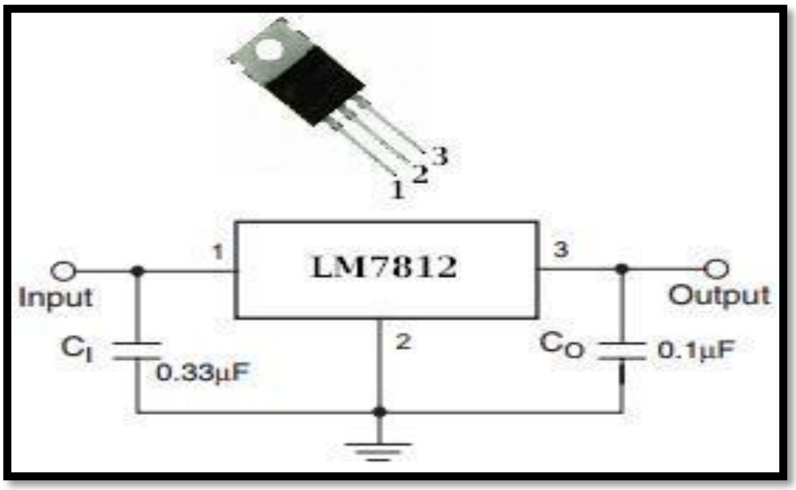

Fig.3.4.2: 7812 voltage regulator with pinout

3.5 LIQUID CRYSTAL DISPLAY

LCD (Liquid Crystal Display) is the innovation utilized in scratch pad shows and other littler PCs. Like innovation for light-producing diode (LED) and gas-plasma, LCDs permit presentations to be a lot slenderer than innovation for cathode beam tube (CRT). LCDs expend considerably less power than LED shows and gas shows since they work as opposed to emanating it on the guideline of blocking light.

An LCD is either made with an uninvolved lattice or a showcase network for dynamic framework show. Likewise alluded to as a meager film transistor (TFT) show is the dynamic framework LCD. The uninvolved LCD lattice has a matrix of conductors at every crossing point of the network with pixels. Two conductors on the lattice send a current to control the light for any pixel. A functioning framework has a transistor situated at every pixel crossing point, requiring less current to control the luminance of a pixel.

Some aloof network LCD's have double filtering, which implies they examine the matrix twice with current in the meantime as the first innovation took one sweep. Dynamic lattice, be that as it may, is as yet a higher innovation.

A 16x2 LCD show is an essential module that is generally utilized in various gadgets and circuits. These modules more than seven sections and other multi fragment LEDs are liked. The reasons being: LCDs are affordable; effectively programmable; have no restriction of showing exceptional and even custom characters (not at all like in seven fragments), movements, etc.

A 16x2 LCD implies 16 characters can be shown per line and 2 such lines exist. Each character is shown in a lattice of 5x7 pixels in this LCD. There are two registers in this LCD, in particular Command and Data. The directions given to the LCD are put away by the order register. An order is a direction given to LCD to play out a predefined assignment, for example, introducing it, clearing its screen, setting the situation of the cursor, controlling presentation, and so forth. The information register will store the information that will be shown on the LCD. The information is the character's ASCII incentive to show on the LCD.

Images of LCD Display:

Fig. 3.5.1: LCD - Front View

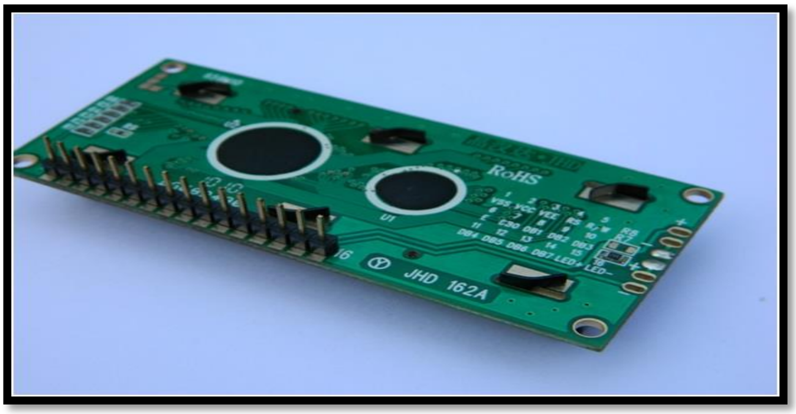

Fig 3.5.2: LCD -Back View

Pin Diagram:

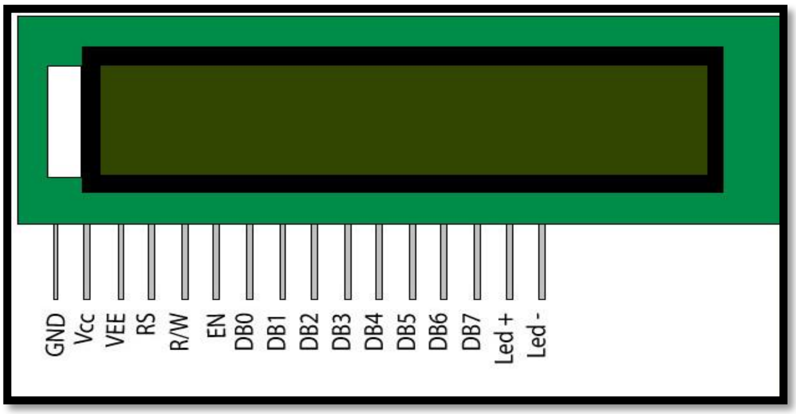

Fig3.5.3: Pin Diagram of LCD

3.5.1 Pin Description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Table 3.5.1: Pin Description of LCD

RS (Register select)

A 16X2 LCD has two order and information registers. The determination of the register is utilized to change starting with one register then onto the next. RS=0 for the register of directions, while RS=1 for the register of information.

Command Register

The guidelines given to the LCD are put away by the direction register. An order is a direction given to LCD to play out a predefined assignment, for example, instating it, clearing its screen, setting the situation of the cursor, controlling showcase, and so on.

Data Register:

The information register will store the information that will be shown on the LCD. The information is the character's ASCII incentive to show on the LCD. It goes to the information register and is prepared there when we send information to the LCD. While choosing RS=1, the information register.

Read and Write Mode of LCD

As stated, the LCD itself comprises of an interface IC. This interface IC can be perused or composed by the MCU. A large portion of the occasions we're simply going to keep in touch with the IC since perusing will make it increasingly perplexing and situations like that are exceptionally uncommon. Information such as cursor position, status completion interrupts, etc. can be read if necessary.

3.5.2 Data/Signals/Execution of LCD

Now that was all about the signals and the hardware. Let us come to data, signals and execution. Two types of signals are accepted by LCD, one is data and one is control. The LCD module recognizes these signals from the RS pin status. By pulling the R / W pin high, data can now also be read from the LCD display. Once the E pin has been pulsed, the LCD display reads and executes data at the falling edge of the pulse, the same for the transmission case.

It takes 39-43µS for the LCD display to place a character or execute a command. It takes 1.53ms to 1.64ms except for clearing display and searching for cursor to the home position. Any attempt to send data before this interval may result in failure in some devices to read data or execute the current data. Some devices compensate for the speed by storing some temporary registers with incoming data.

There are two RAMs for LCD displays, namely DDRAM and CGRAM. DDRAM registers the position in which the character would be displayed in the ASCII chart. Each DDRAM byte represents every single position on the display of the LCD. The DDRAM information is read by the LCD controller and displayed on the LCD screen.

CGRAM enables users to define their personalized characters. Address space is reserved for users for the first 16 ASCII characters. Users can easily display their custom characters on the LCD screen after CGRAM has been set up to display characters.

3.5.3 Block Diagram of LCD Display

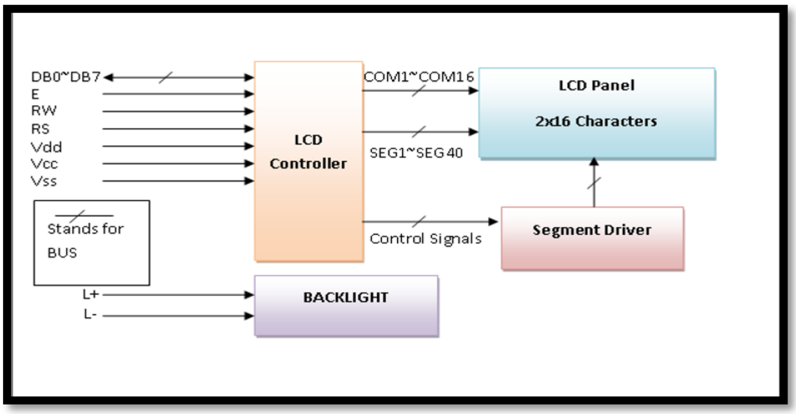

Fig.3.5.3: Block Diagram of LCD Display

Control and display commands

Instruction	**Instruction Code**										**Instruction Code Description**	**Execution time**
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Read Data From RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM	1.53-1.64ms
Write data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM)	1.53-1.64ms
Busy flag & Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Busy flag (BF: 1→ LCD Busy) and contents of address counter in bits AC6-AC0.	39 μs

Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter.	39 µs
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM Address in address counter.	39 µs
Function Set	0	0	0	0	1	DL	N	F	X	X	Set interface data length (DL: 4bit/8bit), Numbers of display line (N: 1-line/2-line) display font type (F:0→ 5×8 dots, F:1→ 5×11 dots)	39 µs
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	X	X	Set cursor moving and display shift control bit, and the direction without changing DDRAM data	39 µs

Display & Cursor On/Off	0	0	0	0	0	0	1	D	C	B	Set Display(D), Cursor(C) and cursor blink(b) on/off control	39 µs
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction and enable shift entire display.	0µs
Return Home	0	0	0	0	0	0	0	0	1	X	Set DDRAM Address to “00H” from AC and return cursor to its original position if shifted.	43µs
Clear Display	0	0	0	0	0	0	0	0	0	1	Write “20H” to DDRAM and set DDRAM Address to “00H” from AC	43µs

Table 3.5.3: Control And Display Commands of LCD

3.6 RELAY

A relay is an electromagnetic switch that is used to turn on and turn off a circuit by a low power signal, or where several circuits must be controlled by one signal. Most of the high-end industrial application devices have relays for their effective working. Relays are simple switches which are operated both electrically and mechanically. Relays consist of an electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. There are also other operating principles for its working. But they differ according to their applications. Most of the devices have the application of relays.

Relay is one kind of electro-mechanical component that functions as a switch. The relay coil is energized by DC so that contact switches can be opened or closed. A single channel 5V relay module generally includes a coil, and two contacts like normally open (NO) and normally closed (NC). This article discusses an overview of the 5V relay module & it’s working but before going to discuss what is relay module is, first we have to know what is relay and its pin configuration.

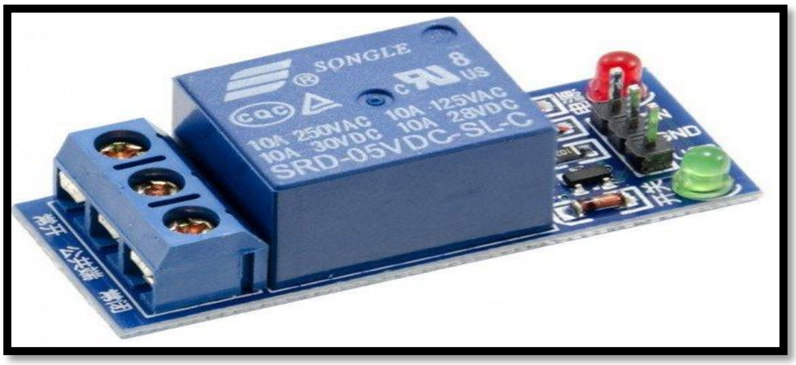

Fig.3.6.1: Relay Module

Fig.3.6.2: Pin Diagram of Relay

3.7 DC Water Pump

DC powered pumps use direct current from motor, battery, or solar power to move fluid in a variety of ways. Motorized pumps typically operate on 6, 12, 24, or 32 volts of DC power. Solar-powered DC pumps use photovoltaic (PV) panels with solar cells that produce direct current when exposed to sunlight.

DC water pump is a electric water pump driven by a DC motor. AC water pump is driven by an AC motor. Why do people more prefer to use DC pumps powered by 12v, 24v, 5v, 6v instead of ac water pump powered by 120v, 220v, 240v, and 380v in many applications. If you don’t know the advantages of the dc pump when compared with ac water pump which led to people more prefer dc electric water pump, you can find the answer from the following content:

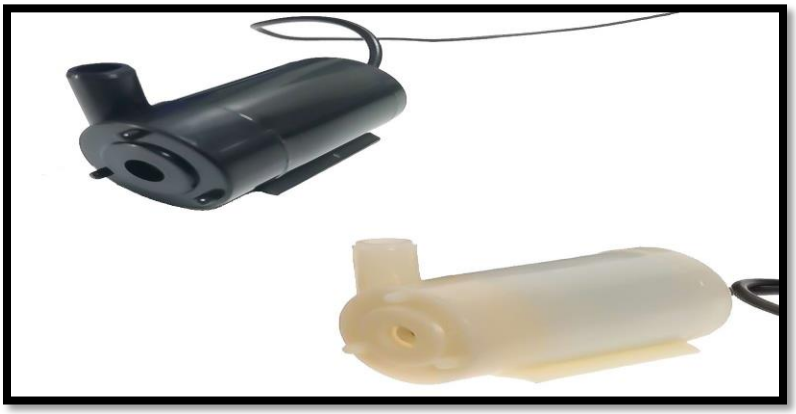

Fig.3.7: DC Water Pump

DC Pump Classification:

1. Brush Dc Water Pump
2. Brushless DC magnetic drive isolated water pump
3. Brushless motor DC Water pump

3.8 BATTERY

A rechargeable battery is an energy storage device that can be charged again after being discharged by applying DC current to its terminals.

In use, rechargeable batteries are the same as conventional ones. However, after discharge the batteries are placed in a charger or, in the case of built-in batteries, an AC/DC adapter is connected.

While rechargeable batteries offer better long-term cost and reduce waste, they do have a few cons. Many types of rechargeable cells created for consumer devices, including AA and AAA, C and D batteries, produce a lower voltage of 1.2v in contrast to the 1.5v of alkaline batteries. Though this lower voltage doesn't prevent correct operation in properly-designed electronics, it can mean a single charge does not last as long or offer the same power in a session. This is not the case, however, with lithium polymer and lithium-ion batteries.

Some types of batteries such as nickel cadmium and nickel-metal hydride can develop a battery memory effect when only partially discharged, reducing performance of subsequent charges and thus battery life in a given device.

Fig.3.8: 12V Battery

3.9 SOLAR PANEL

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged, connected assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications.

Solar panels are devices that convert sunlight into electricity. They consist of many smaller units called photovoltaic cells, which are typically made from semiconductor materials such as silicon. When sunlight strikes these cells, it excites electrons within the material, creating an electric current. The efficiency and performance of solar panels depend on various factors, including the type of semiconductor material used, the quality of manufacturing, and environmental conditions like sunlight intensity and temperature. They are used in a wide range of applications, from powering individual homes and businesses to large-scale solar farms that feed electricity into the grid. The voltage produced by a solar panel depends on several factors, including the characteristics of the photovoltaic cells, the amount of sunlight hitting the panel, and the temperature.

Cell Characteristics: The voltage output of a solar panel is determined by the properties of the individual photovoltaic cells within it. Different types of solar cells have different voltage characteristics. For example, monocrystalline silicon solar cells tend to have higher voltage outputs compared to polycrystalline silicon cells.

Sunlight Intensity: The amount of sunlight hitting the solar panel directly affects its voltage output. Higher sunlight intensity leads to higher voltage output, while lower sunlight intensity results in lower voltage.

Temperature: Solar panels are more efficient at cooler temperatures, but their voltage output decreases as temperature rises. This is due to the negative temperature coefficient of most solar cells, meaning that as temperature increases, the voltage decreases.

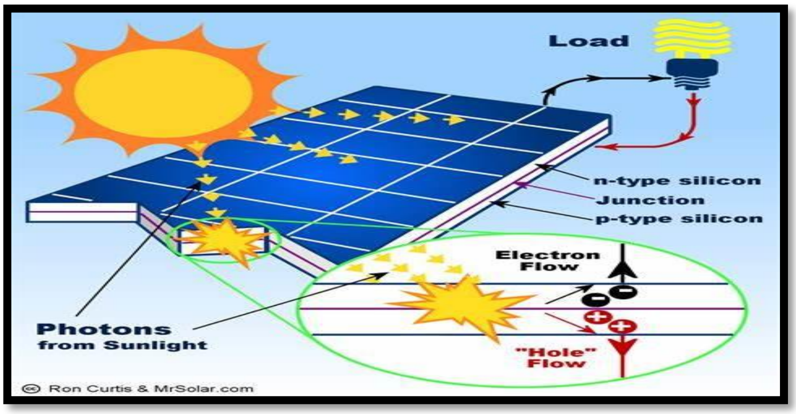

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Fig.3.9: Thin Solar Plate

3.10 VOLTAGE SENSOR

This sensor is used to monitor, calculate and determine the voltage supply. This sensor can determine the AC or DC voltage level. The input of this sensor can be the voltage whereas the output is the switches, analog voltage signal, a current signal, an audible signal, etc. Some sensors provide sine waveforms or pulse waveforms like output & others can generate outputs like AM (Amplitude Modulation), PWM (Pulse Width Modulation) or FM (Frequency Modulation). The measurement of these sensors can be divider.

Input Voltage (V)	0 to 25
Voltage Detection Range (V)	0.02445 to 25
Analog Voltage Resolution (V)	0.00489
Length (mm)	28
Width (mm)	14
Height (mm)	13
Weight (gm)	4

Table 3.10: Specifications of Voltage Sensor

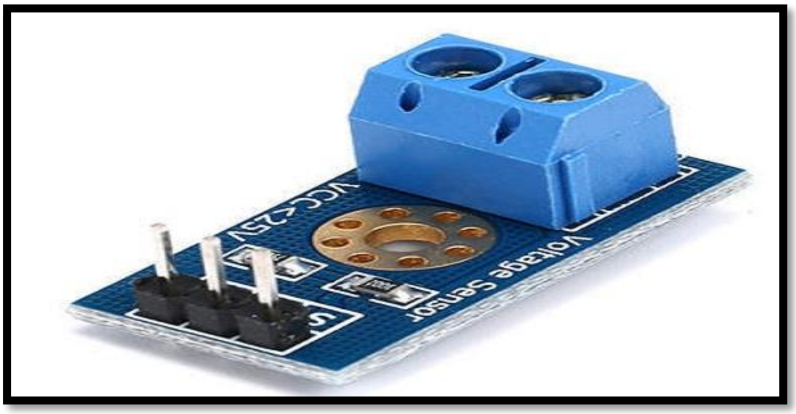


Fig.3.10: Voltage Sensor

3.11 DHT 11 SENSOR

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds. The DHT11 is a commonly used **Temperature and humidity sensor** that comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. Humidity is the measure of water vapour present in the air. The level of humidity in air affects various physical, chemical and biological processes. In industrial applications, humidity can affect the business cost of the products, health and safety of the employees. So, in Semiconductor industries and control system industries measurement of humidity is very important. Humidity measurement determines the amount of moisture present in the gas that can be a mixture of water vapour, nitrogen, argon or pure gas etc.… Humidity sensors are of two types based on their measurement units. They are a relative humidity sensor and Absolute humidity sensor. DHT11 is a digital temperature and humidity sensor.

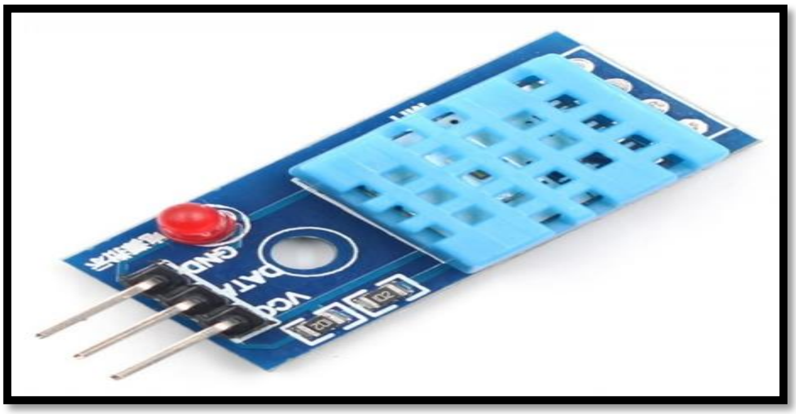


Fig.3.11: DHT 11 Sensor

3.12 NodeMCU

3.12.1 Introduction to NodeMCU

Node MCU is an open-source firmware and development kit that plays a vital role in designing your own IoT product using a few Lua script lines. Multiple GPIO pins on the board allow you to connect the board with other peripherals and are capable of generating PWM, I2C, SPI, and UART serial communications.

The interface of the module is mainly divided into two parts including both Firmware and Hardware where former runs on the ESP8266 Wi-Fi SoC and later is based on the ESP-12 module. The firmware is based on Lua – A scripting language that is easy to learn, giving a simple programming environment layered with a fast-scripting language that connects you with a well-known developer community.

The NodeMCU is a popular open-source development board based on the ESP8266 microcontroller. It combines the capabilities of Wi-Fi connectivity with a microcontroller, making it ideal for IoT (Internet of Things) projects. Here are some common uses of the NodeMCU:

Home Automation: NodeMCU can be used to build home automation systems that allow users to control lights, appliances, and other devices remotely over Wi-Fi. For example, you can create a smart lighting system that turns lights on and off based on certain triggers or schedules.

Weather Stations: With its Wi-Fi capabilities, NodeMCU can collect sensor data such as temperature, humidity, and air pressure and send it to a cloud server for analysis or display. This data can be used to create DIY weather stations or environmental monitoring systems.

Smart Agriculture: NodeMCU can be used in agricultural applications to monitor soil moisture levels, temperature, and other environmental factors. This data can help farmers optimize irrigation schedules and crop growth conditions.

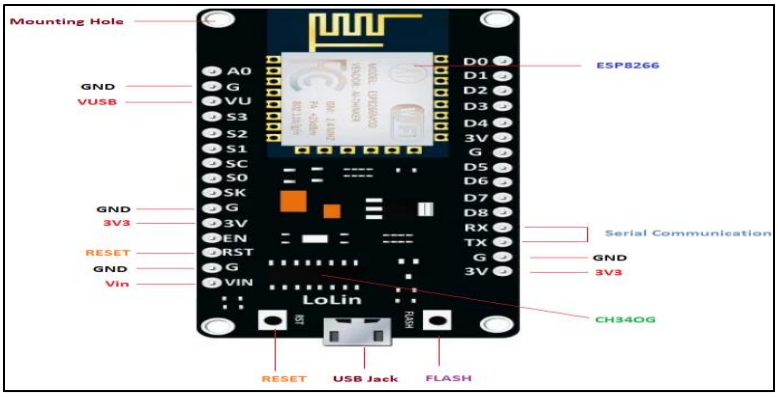


Fig.3.12.1: Pin Diagram of NodeMCU

And open-source firmware gives you the flexibility to edit, modify and rebuilt the existing module and keep changing the entire interface until you succeed in optimizing the module as per your requirements' to UART converter is added on the module that helps in converting USB data to UART data which mainly understands the language of serial communication. Instead of the regular USB port, MicroUSB port is included in the module that connects it with the computer for dual purposes: programming and powering up the board.

3.12.2 NodeMCU Pinout

NodeMCU comes with a number of GPIO Pins. Following figure shows the Pinout of the board.

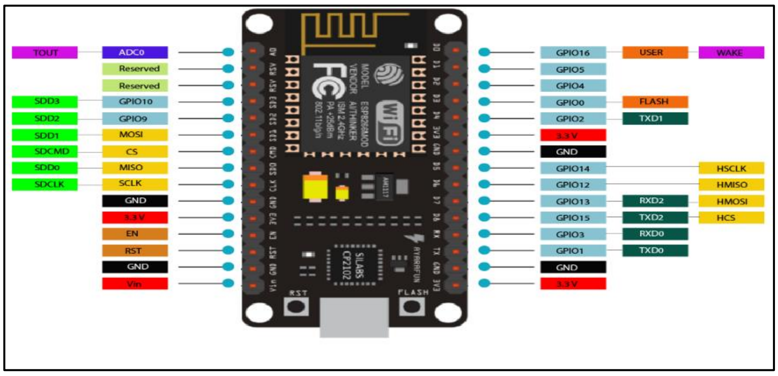


Fig.3.12.2: NodeMCU Pinout

There is a candid difference between VIN and VU where former is the regulated voltage that may stand somewhere between 7 to 12 V while later is the power voltage for USB that must be kept around 5 V.

Features:

- Open-source
- Arduino-like hardware
- Status LED
- MicroUSB port
- Reset/Flash buttons
- Interactive and Programmable
- Low cost
- ESP8266 with inbuilt WIFI
- USB to UART converter
- GPIO pins

As mentioned above, a cable supporting micro-USB port is used to connect the board. As you connect the board with a computer, LED will flash. You may need some drivers to be installed on your computer if it fails to detect the NodeMCU board. You can download the driver from this page.

Note: We use Arduino Ide software for programming this module. It is important to note that the pin configuration appearing on the board is different from the configuration we use to program the board on the software i.e. when we write code for targeting pin 16 on the Arduino IDE, it will actually help is laying out the communication with the D0 pin on the module.

Following figure, the shows the pin configuration to use in Arduino IDE.

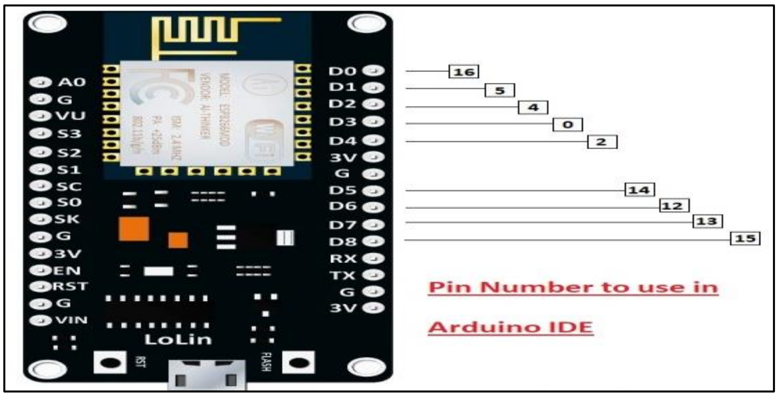


Fig.3.12: Pin numbers of NodeMCU

How to Power NodeMCU:

You can see from the pinout image above, there are five ground pins and three 3V3 pins on the board. The board can be powered up using the following three ways.

USB Power. It proves to an ideal choice for loading programs unless the project you aim to design requires separate interface i.e. disconnected from the computer.

Provide 3.3V. This is another great option to power up the module. If you have your own off-board regulator, you can generate an instant power source for your development kit.

Power Vin. This is a voltage regulator that comes with the ability to support up to 800 mA. It can handle somewhere between 7 to 12 V. You cannot power the devices operating at 3.3 V, as this regulator unable to generate as low as 3.3V.The NodeMCU is a popular open-source development board based on the ESP8266 microcontroller. It combines the capabilities of Wi-Fi connectivity with a microcontroller, making it ideal for IoT (Internet of Things) projects. the NodeMCU.

3.12.3 Applications

NodeMCU V3 is mainly used in the WIFI Applications which most of the other embedded modules fail to process unless incorporated with some external WIFI protocol. Following are some major applications used for NodeMCU V3.

Internet Smoked Alarm

- VR Tracker
- Octopod
- Serial Port Monitor
- ESP Lamp
- Incubator Controller
- IoT home automation
- Security Alarms

3.13 Motor Driver

A motor driver is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver act as an interface between Arduino and the motors. The most commonly used motor driver ICs are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. We will be referring the motor driver IC as L293D only. L293D has 16 pins. The L293D is a 16 pin IC, with eight pins, on each side, dedicated to the controlling of a motor. There are 2 INPUT pins, 2 OUTPUT pins and 1 ENABLE pin for each motor. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor.

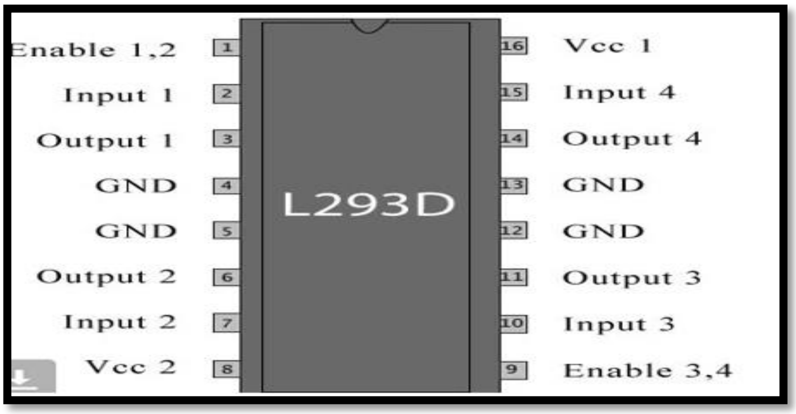


Fig.3.13.1: Pin Diagram of Motor Driver

WORKING OF MOTOR DRIVER

There are 4 input pins for l293d, pin 2, 7 on the left and pin 15, 10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right-hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.

In simple you need to provide Logic 0 or 1 across the input pins for rotating the motor.

L293D Logic Table.

Let's consider a Motor connected on left side output pins (pin 3, 6). For rotating the motor in clockwise direction, the input pins have to be provided with Logic 1 and Logic 0.

Pin 2 = Logic 1 and Pin 7 = Logic 0 | Clockwise Direction

Pin 2 = Logic 0 and Pin 7 = Logic 1 | Anticlockwise Direction

Pin 2 = Logic 0 and **Pin 7 = Logic 0** | Idle [No rotation] [Hi-Impedance state]

Pin 2 = Logic 1 and **Pin 7 = Logic 1** | Idle [No rotation]

Circuit Diagram for l293d motor driver IC controller

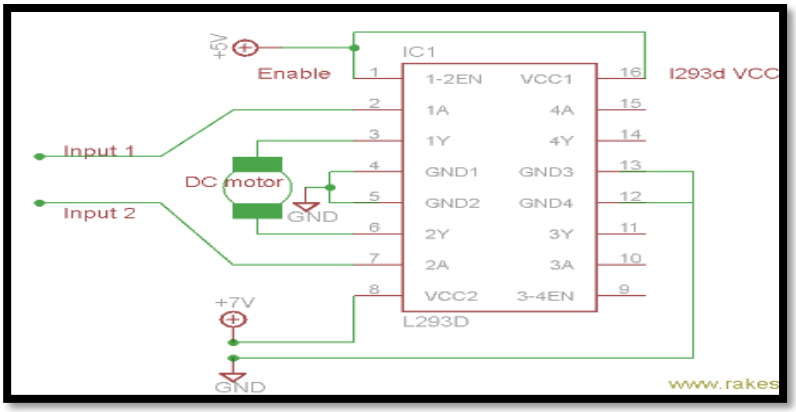


Fig.3.13.2: Circuit Diagram for l293d motor driver

Voltage Specification of Motor Driver

VCC is the voltage that it needs for its own internal operation 5v; L293D will not use this voltage for driving the motor. For driving the motors, it has a separate provision to provide motor supply VSS (V supply). L293d will use this to drive the motor. It means if you want to operate a motor at 9V then you need to provide a Supply of 9V across VSS Motor supply.

3.14 DC Motor

A Direct current (DC) motor is a type of electric machine that converts electrical energy into mechanical energy. DC motors take electrical power through direct current, and convert this energy into mechanical rotation. DC motors use magnetic fields that occur from the electrical currents generated, which powers the movement of a rotor fixed within the output shaft. The output torque and speed depend upon both the electrical input and the design of the motor.

DC motors are commonly used in various cleaning processes due to their versatility, reliability, and controllability. Here are several ways DC motors are utilized in cleaning applications:

Vacuum Cleaners: DC motors power the suction mechanism in vacuum cleaners. These motors provide the necessary torque to drive the fan blades, creating airflow that sucks in dirt, dust, and debris from surfaces. The speed and power of the DC motor can be adjusted to control the suction strength of the vacuum cleaner.

Pressure Washers: DC motors power the pumps in pressure washers. These motors generate the high-pressure water flow needed to blast away dirt, Mold, mildew, and other contaminants from surfaces such as sidewalks, driveways, decks, and vehicles.

The speed and pressure output of the motor can be adjusted to suit the cleaning requirements.
Overall, DC motors play a crucial role in various cleaning processes, providing the power and control necessary to achieve effective and efficient cleaning results in both residential and commercial settings.

Fig.3.14: DC Motor

3.15 Servo Motor

A **servo motor** is a type of motor that can rotate with great precision. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. If you want to rotate an object at some specific angles or distance, then you use a servo motor. It is just made up of a simple motor which runs through a **servo mechanism.**

Fig3.15: Servo Motor

Servo Motor Working Mechanism

It consists of three parts:

- Controlled device
- Output sensor
- Feedback system

It is a closed-loop system where it uses a positive feedback system to control motion and the final position of the shaft.

3.16 ARDUINO UNO

The Uno with Cable is a micro-controller board base on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs); 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

It contains everything need to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. “Uno” means one in Italian and is the name to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Note: The Uno R3 reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

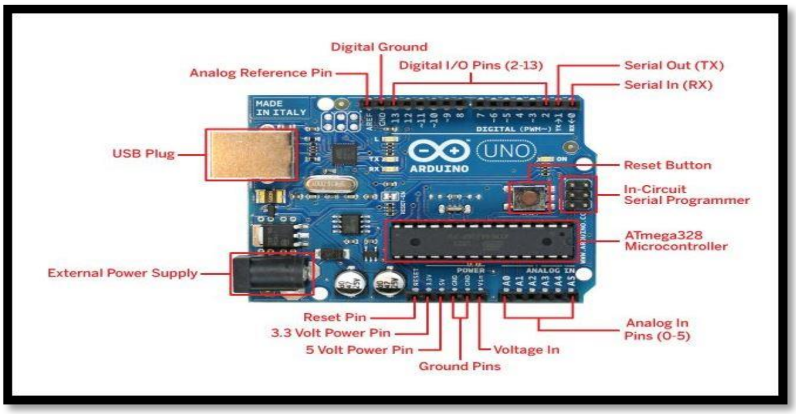


Fig.3.16: Arduino Uno

CHAPTER - IV

CONSTRUCTION&WORKING

4.1 BLOCK DIAGRAM

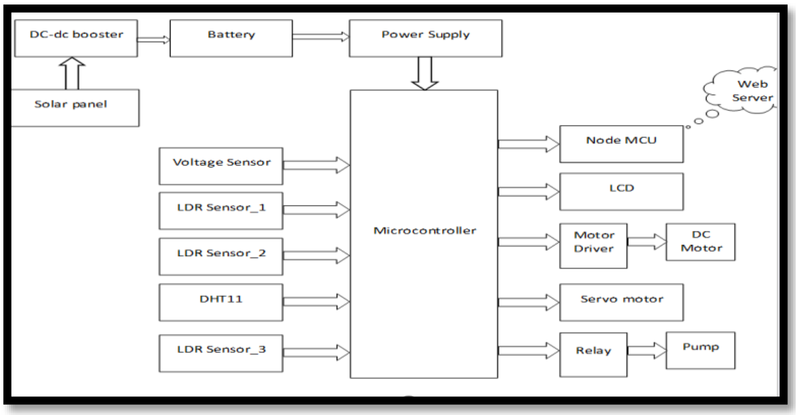


Fig.4.1: Block Diagram of IOT Based Automated Solar Panel Cleanging&Monitoring Technique

4.2 WORKING PROCESS

According to this block diagram, the solar panel produces electrical power from the sun's light energy and the battery stores that power through the charger. However, the output power level depends on the extent of dust and dirt aggregated on the exterior of the panel.

The NodeMCU is then attached to collect data from the solar panel's output of the voltage and LDR sensors. The Arduino microcontroller is connected to the I2C LCD driver, which displays the data collected from the solar panel. The cleaning brush is connected to the servo motor's output shaft to clean the solar panel's surface. The submersible pump is linked to the water reservoir so that it can spray water on the solar panel when it gets dirty. The submersible pump is driven by a DC motor, which is activated by a relay module. The relay module gets the excitation signal from the microcontroller based on the cleaning requirement.

The voltage sensor detects the voltage level of the solar panel and the LDR sensor detects the amount of sunlight falling on it. Thus, the LDR sensor gives a signal to the microcontroller regarding the intensity level of the sunlight. So, if the solar panel's output voltage level falls below a specified threshold level, then the microcontroller can detect whether the solar panel is dirty or not by comparing the detected voltage levels of these two sensors. The system is programmed to activate the water pump and cleaning brush based on this comparison. The servo motor alternately turns the cleaning brush, while the submersible DC motor-driven pump lifts water from the reservoir to the solar panel for cleaning. The system is connected to the cloud server via an IoT to ensure that the user can monitor the system's performance remotely and make necessary adjustments. It helps in collecting data from the solar panel, monitoring the voltage generated, and automating the cleaning process. The reasons for using various components are explained in the next sub-Sections.

The NodeMCU based on the ESP8266 Wi-Fi module is used in this work to integrate different components connected via various sensors and devices to have a robust network. It has voltage regulators, USB to serial converters, numerous input/output pins, etc. It can accommodate diverse ranges of sensors readily and supports the Arduino IDE platform to write programming languages for it. The NodeMCU is responsible for collecting data from the solar panel and transmitting it to the LCD device for visualization.

Lithium-ion (Li-ion) rechargeable battery is used in this work because it is very eco-friendly, possesses very high energy density, and lower rates of self-discharge. During the discharging and recharging cycles, it undergoes movement of charged particles through cathodes and anodes to create current flow. Therefore, it can be reused several times. So, it provides a cost-efficient long-term solution. Besides, it is a lightweight and safe device for its users.

In this work, a monocrystalline mini solar panel was used having a battery capacity of up to 200 Mah at 6 V to test our designed system's functionality. The panel converts light radiation from the sun into usable electricity. It produces more energy per square inch. It can deliver electric power over extended periods, even when direct sunlight is unavailable.

Controlling any device driven by high voltage and current requires low voltage and current signals. In such cases, the relay module is highly effective. It works like an electrical switch that opens or closes mechanical or magnetic circuits to regulate electricity flow at high voltage and high current. A control circuit processes the control signals to activate relays. In this work, we used a relay module of 5 V DC to 250 V AC having an AC rating of 10 A and a response time of around 1s. It serves as a switch to turn the DC motor ON and OFF.

A mini submersible DC motor pump was used in this work to lift water from the underground reservoir during the solar panel cleaning process. This type of small-sized and robust pump consumes very low power at high efficiency and can pump water without priming. These pumps are manufactured to provide increased lifespan.

4.3 WORKING PRINCIPLE

An IoT-based automated solar panel cleaning and monitoring technique typically involves the integration of sensors, actuators, and communication devices with solar panels to automate the cleaning process and monitor their performance remotely. Here's a general overview of how such a system works:

Sensor Deployment: Sensors are installed on the solar panels to collect data related to various parameters such as solar irradiance, temperature, humidity, and so on. These sensors help in monitoring the environmental conditions affecting the performance of the solar panels.

Data Collection: The sensors continuously collect data from the solar panels and transmit it to a central control unit or a cloud-based platform via wireless communication protocols such as Wi-Fi, Zigbee, or LoRa.

Data Analysis: The collected data is then analyzed to assess the efficiency and performance of the solar panels. Algorithms may be employed to detect patterns, anomalies, or deviations from the expected performance metrics.

Cleaning Decision: Based on the analysis of the collected data, the system decides whether the solar panels require cleaning or not. Factors such as the amount of dust accumulation, reduction in solar irradiance, and historical performance data may be considered in making this decision.

Cleaning Process: The cleaning mechanism, depending on the design, could involve various techniques such as brushing, spraying water, or using cleaning solutions to remove dust, dirt, or other debris from the surface of the solar panels.

Data Reporting & Visualization: The collected data, including performance metrics, cleaning history, and environmental conditions, can be visualized through a dashboard or mobile application. This allows users to track the overall efficiency of the solar panels and make informed decisions regarding maintenance and optimization

4.4 WORKING OF FLOWCHART

The flow chart of the IoT-based automated solar panel cleaning scheme is shown in Fig. 3. As per the flow chart, the program initializes the variables at the start of the system. Then it scans the input ports of the microcontroller to read the LDR and voltage sensors sensor's data. After that, the data is analyzed by the microcontroller according to its assembly language program. If it detects a HIGH signal, then the program sends HIGH signals to both output terminals connected to the servo and DC motors. The servo motor actuates the cleaning brush, and the DC motor is activated via a relay module to spray water on the solar panel. However, if no dust is detected, then the program remains in the loop of scanning the two sensors' data.

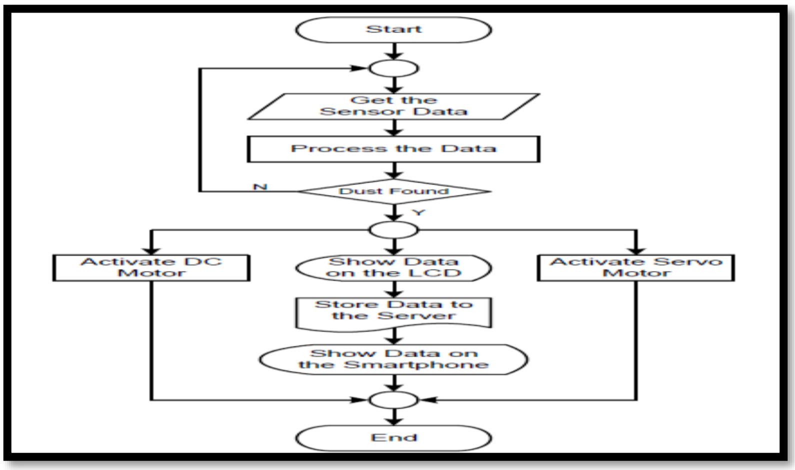


Fig.4.4: Flow chart of an IoT-based automated Solar Panel Cleaning Management

4.5 ADVANTAGES

- Automation
- Compactness
- Integration
- Cost-effectiveness
- Energy-efficient
- Scalability
- Connectivity.
- Efficiency

4.6 DISADVANTAGES

- Increased operation and maintenance cost due to presence of commutator and brushgear.
- It is useful for the low voltage inputs because Arduino can’t supply more input voltage
- If the distance becomes more the cost will be increased

4.7 APPLICATIONS

- Houses
- Industries
- Energy Management Systems
- Smart Agriculture

CHAPTER- V

SOFTWARE DESCRIPTION

5.1 SOFTWARE USED

Arduino IDE:

Arduino IDE where IDE stands for Integrated Development Environment – An official software introduced by Arduino.cc, that is mainly used for writing, compiling and uploading the code in the Arduino Device. Almost all Arduino modules are compatible with this software that is an open source and is readily available to install and start compiling the code on the go.

Introduction to Arduino IDE

Arduino IDE is an open-source software that is mainly used for writing and compiling the code into the Arduino Module.

It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

It is easily available for operating systems like MAC, Windows, and Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and compiling the code in the environment.

A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro, and many more. Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code. The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.

The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

How to install Arduino IDE

You can download the Software from Arduino main website. As I said earlier, the software is available for common operating systems like Linux, Windows, and MAX, so make sure you are downloading the correct software version that is easily compatible with your operating system. If you aim to download Windows app version, make sure you have Windows 8.1 or Windows 10, as app version is not compatible with Windows 7 or older version of this operating system.

The IDE environment is mainly distributed into three sections

1. Menu Bar

2. Text Editor

3. Output Pane

As you download and open the IDE software, it will appear like an image below.

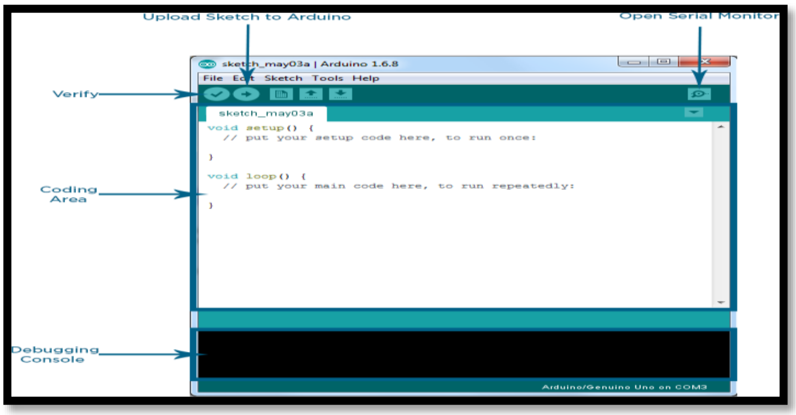
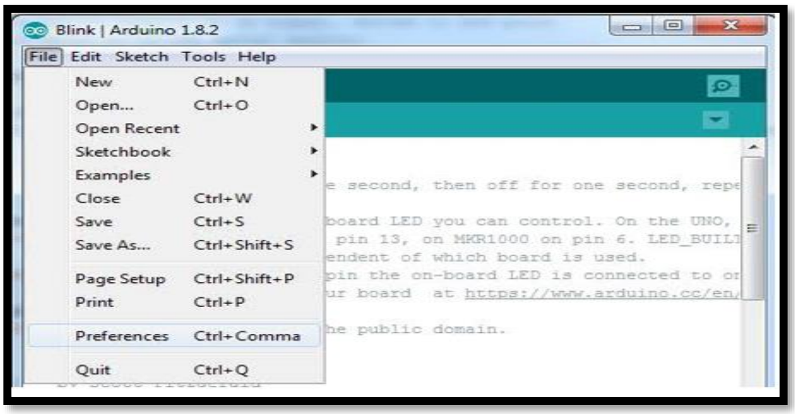


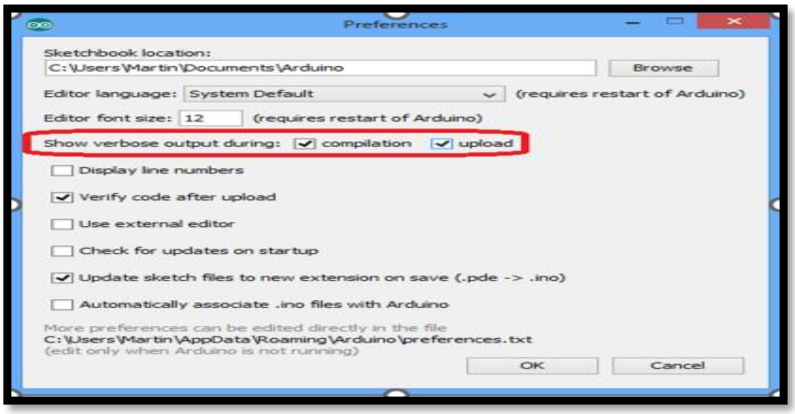
Fig. 5.1: Arduino IDE Default window

The bar appearing on the top is called **Menu Bar** that comes with five different options as follow

File – You can open a new window for writing the code or open an existing one. Following table shows the number of further subdivisions the file option is categorized into.



As you go to the preference section and check the compilation section, the Output Pane will show the code compilation as you click the upload button.



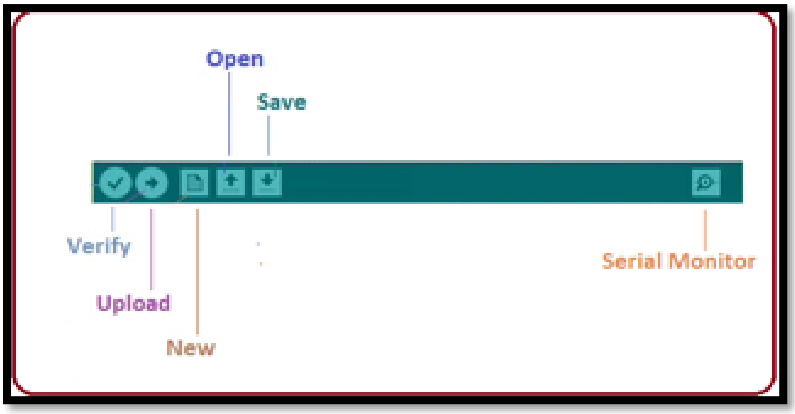
And at the end of compilation, it will show you the hex file it has generated for the recent sketch that will send to the Arduino Board for the specific task you aim to achieve.

- Edit – Used for copying and pasting the code with further modification for font

Sketch – For compiling and programming

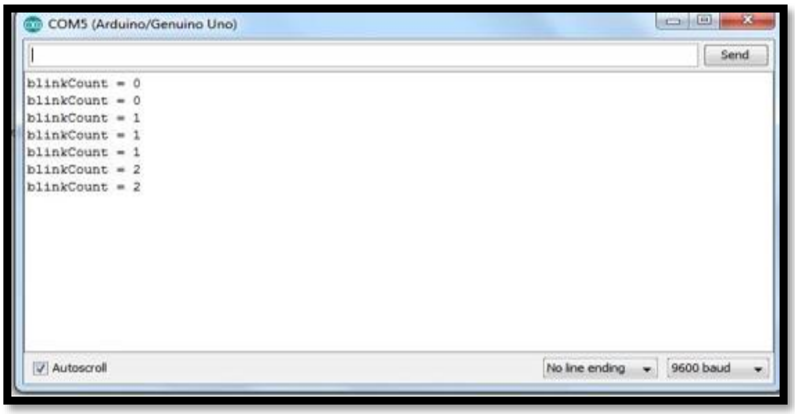
- Tools – Mainly used for testing projects. The Programmer section in this panel is used for burning a bootloader to the new microcontroller.
- Help – In case you are feeling skeptical about software, complete help is available from getting started to troubleshooting.

The Six Buttons appearing under the Menu tab are connected with the running program as follow.



- The check mark appearing in the circular button is used to verify the code. Click this once you have written your code.
- The arrow key will upload and transfer the required code to the Arduino board.
- The dotted paper is used for creating a new file.
- The upward arrow is reserved for opening an existing Arduino project.
- The downward arrow is used to save the current running code.
- The button appearing on the top right corner is a Serial Monitor – A separate pop-up window that acts as an independent terminal and plays a vital role for sending and receiving the Serial Data.
- You can also go to the Tools panel and select Serial Monitor, or pressing Ctrl+Shift+M all at once will open it instantly. The Serial Monitor will actually help to debug the written Sketches where you can get a hold of how your program is operating.
- Your Arduino Module should be connected to your computer by USB cable in order to activate the Serial Monitor.

You need to select the baud rate of the Arduino Board you are using right now. For my Arduino Uno Baud Rate is 9600, as you write the following code and click the Serial Monitor, the output will show as the image below.



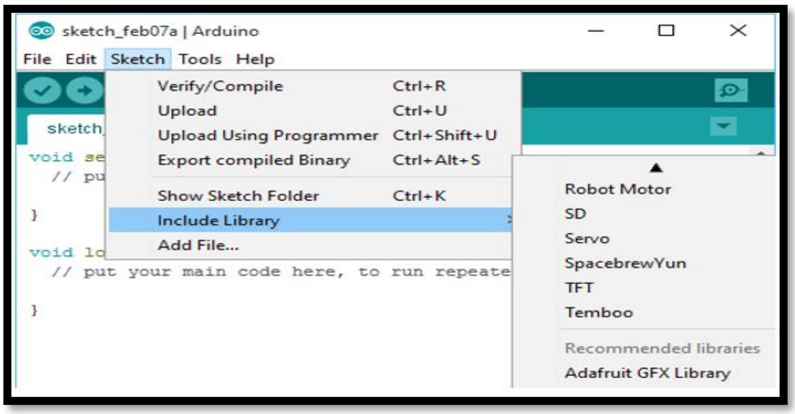
The main screen below the Menu bard is known as a simple text editor used for writing the required code.

The bottom of the main screen is described as an Output Pane that mainly highlights the compilation status of the running code: the memory used by the code, and errors occurred in the program. You need to fix those errors before you intend to upload the hex file into your Arduino Module.

More or less, Arduino C language works similar to the regular C language used for any embedded system microcontroller, however, there are some dedicated libraries used for calling and executing specific functions on the board.

Libraries:

Libraries are very useful for adding the extra functionality into the Arduino Module. There is a list of libraries you can add by clicking the Sketch button in the menu bar and going to Include Library.



As you click the Include Library and Add the respective library it will on the top of the sketch with a #include sign. Suppose, I Include the EEPROM library, it will appear on the text editor as

#include <EEPROM.h>.

Most of the libraries are preinstalled and come with the Arduino software. However, you can also download them from the external sources.

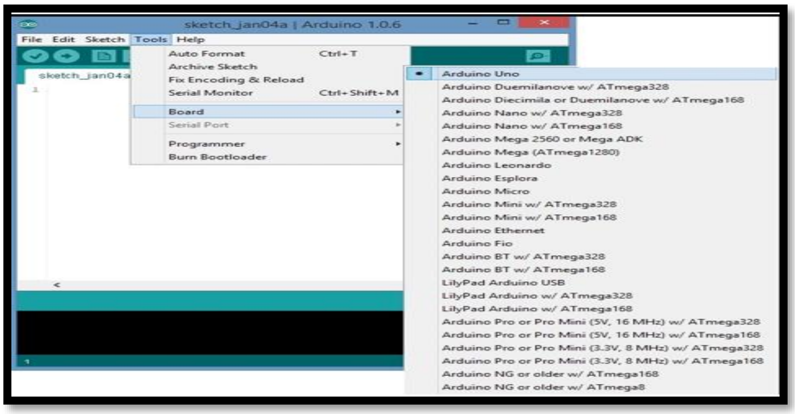
Making pins Input and output:

The digital Read and digitalWrite commands are used for addressing and making the Arduino pins as an input and output respectively.

These commands are text sensitive i.e. you need to write them down the exact way they are given like digitalWrite starting with small "d" and write with capital "W". Writing it down with DigitalWrite or digitalWrite won't be calling or addressing any function.

How to select the board:

In order to upload the sketch, you need to select the relevant board you are using and the ports for that operating system. As you click the Tools on the Menu, it will open like the figure below. Just go to the "Board" section and select the board you aim to work on. Similarly, COM1, COM2, COM4, COM5, COM7 or higher are reserved for the serial and USB board. You can look for the USB serial device in the ports section of the Windows Device Manager. Following figure shows the COM4 that I have used for my project, indicating the Arduino Uno with COM4 port at the right bottom corner of the screen.



After correct selection of both Board and Serial Port, click the verify and then upload button appearing in the upper left corner of the six-button section or you can go to the Sketch section and press verify/compile and then upload.

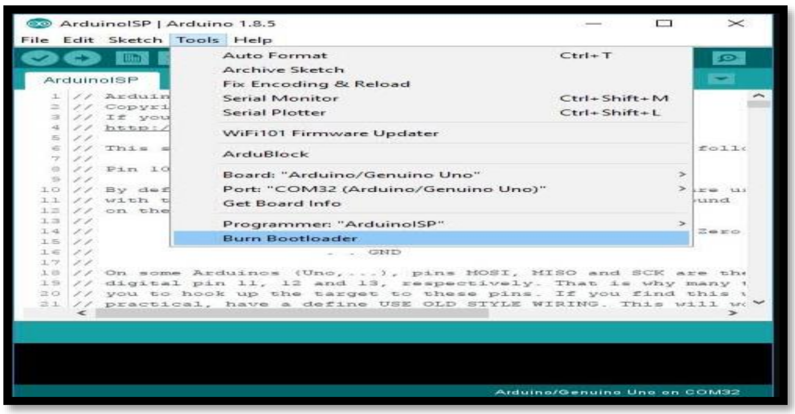
The sketch is written in the text editor and is then saved with the file extension. ino.

It is important to note that the recent Arduino Modules will reset automatically as you compile and press the upload button the IDE software, however, older version may require the physical reset on the board.

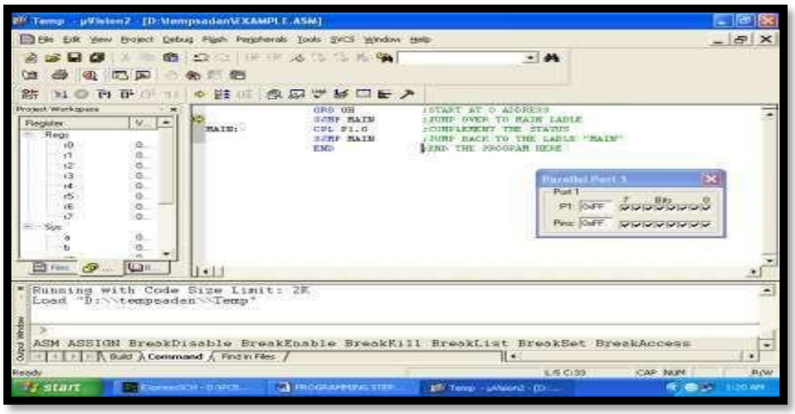
Once you upload the code, TX and RX LEDs will blink on the board, indicating the desired program is running successfully.

Bootloader:

As you go to the Tools section, you will find a bootloader at the end. It is very helpful to burn the code directly into the controller, setting you free from buying the external burner to burn the required code.



When you buy the new Arduino Module, the bootloader is already installed inside the controller. However, if you intend to buy a controller and put in the Arduino module, you need to burn the bootloader again inside the controller by going to the Tools section and selecting the burn bootloader.



Now keep Pressing function key “F11” slowly and observe.

You are running your program successful

5.2 Thing Speak IoT Platform

Thing Speak is IoT platform for user to gather real-time data; for instance, climate information, location data and other device data. In different channels in Thing Speak, you can summarize information and visualize data online in charts and analyze useful information. Thing Speak can integrate IoT: bit (micro: bit) and other software/ hardware platforms. Through IoT: bit, you can upload sensors data to Thing Speak (e.g. temperature, humidity, light intensity, noise, motion, raindrop, distance and other device information).

Fig. 5.2: Things Speak Configuration

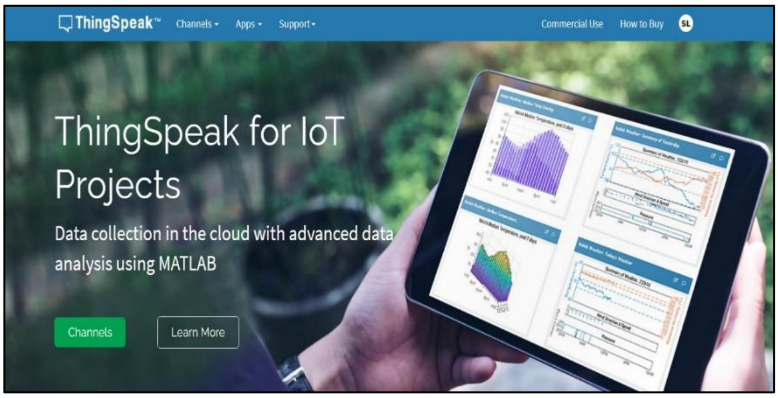
5.2.1. Thing speak Configuration

Goal:

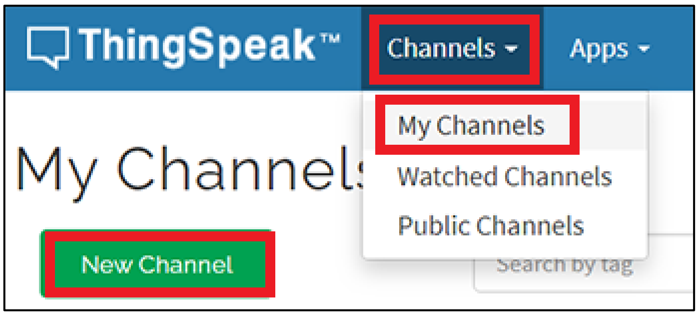
we need to create the thing speak channel and get the key

Step 1

Go to https://thingspeak.com/, register an account and login to the platform



Step 2
Choose Channels -> My Channels -> New Channel



Step 3

Input Channel name, Field1, then click "Save Channel"

5.3 Machine Learning with Python

Machine learning can be utilized in hardware projects to enhance functionality, optimize performance, and enable intelligent decision-making. Here's how you can integrate machine learning into hardware projects using Python:

Predictive Maintenance: Use machine learning algorithms to predict when hardware components are likely to fail. By analysing historical data from sensors or monitoring systems, you can train models to detect patterns indicative of impending failures. Python libraries such as scikit-learn, TensorFlow, or PyTorch can be used for building predictive maintenance models.

Detection: Implement anomaly detection algorithms to identify usual behaviour or deviations from expected performance in hardware systems.

Techniques like Isolation Forests, One-Class SVM, or Autoencoders can be applied for anomaly detection tasks.

Python libraries such as scikit-learn and TensorFlow offer implementations for these algorithms.

Optimization: Utilize machine learning algorithms to optimize hardware configurations or parameters for better performance or energy efficiency.

Techniques like reinforcement learning or genetic algorithms can be employed for optimization tasks. Python libraries such as DEAP, Optuna, or TensorFlow Agents can assist in optimization tasks.

Image And Signal Processing: Apply machine learning techniques for image or signal processing tasks in hardware projects, such as object detection, classification, or noise reduction.

Libraries like OpenCV, scikit-image, or TensorFlow/Keras can be used for image processing tasks, while scipy or PyWavelets can be utilized for signal processing.

Control Systems: Implement machine learning-based control algorithms for autonomous control or system stabilization in hardware projects. Reinforcement learning algorithms like Deep Q-Networks (DQN) or Proximal Policy Optimization (PPO) can be used for control tasks.

Python libraries such as TensorFlow Agents, Stable Baselines, or RLlib can be employed for building and training control systems.

Fault Diagnosis: Develop machine learning models to diagnose faults or abnormalities in hardware systems based on sensor data or system parameters.

Techniques like decision trees, support vector machines (SVM), or deep learning models can be applied for fault diagnosis tasks. Python libraries such as scikit-learn, TensorFlow, or PyTorch can be used for building fault diagnosis models.

Machine learning with python algorithm steps

1. **Define the Problem**: Clearly understand the problem you are trying to solve. Determine whether it's a classification, regression, clustering, or other type of problem.

2. **Data:** Collect the relevant data for your problem. This can involve acquiring datasets from online sources, using APIs, or generating synthetic data.
3. **Preprocess the Data**:
    - **Data Cleaning**: Handle missing values, outliers, and inconsistencies in the data.
    - **Feature Engineering**: Select, transform, or create new features from the raw data to improve model performance.
    - **Feature Scaling**: Normalize or standardize numerical features to ensure they have similar scales.
    - **Feature Selection**: Choose the most relevant features to reduce dimensionality and improve computational efficiency.
4. **Split Data**: Divide the data into training and testing/validation sets. This allows you to train the model on one set of data and evaluate its performance on another set to assess generalization.
5. **Select a Model**: Choose an appropriate machine learning algorithm based on the problem type and data characteristics. Common algorithms include linear regression, decision trees, support vector machines, neural networks, etc.
6. **Train the Model**: Fit the chosen model to the training data. This involves finding the optimal parameters that minimize a chosen loss function.

CHAPTER- VI

RESULTS

RESULTS

6.1 Manual Hardware Kit Diagram

In this System we use Dual-axis types An IoT application's dashboard can be used to automatically or manually track the position of the sun using LDR sensors. LDR sensors provide data to the controller, which determines where the sun is (and as a result, the intensity of its light). A second servomotor (SM1) and a second servomotor (SM2) transform the data into commands to rotate the PV panel in the direction of the sun. In addition, the NodeMCU receives information about temperature, humidity, voltage, and current generated by the PV. Data taken by microcontrollers is sent to the cloud (web server) using an Ethernet shield attached to a NodeMCU. Solar tracking information from the IoT monitoring app can also be viewed in real-time via pre-created widgets. This IoT monitoring app was built in Blynk. The user can view all the solar tracker data on the dashboard of the IoT app when the smartphone or computer is connected to the internet. In this way, PV panels can be monitored for their performance and environmental conditions. When the dashboard widgets that they correspond to are in manual mode, the servo motors will also follow their directions. So, the user can optimize the system so that energy is extracted from the PV panel by finding optimal environmental conditions.

Fig.6.1: Hardware Kit

6.2 Dual-Axis of First LDR Sensor

when mobile flash is on and light is focused to First LDR Sensor Automatically the Solar Panel will be Rotated with the Help of Motor Driver.

Fig .6.2: Dual Axis of First LDR Sensor

6.3 Dual Axis of Second LDR Sensor

when mobile flash is on and light is focused to Second LDR Sensor Automatically the Solar Panel will be Rotated with the Help of Motor Driver.

Fig.6.3: Dual Axis of Second LDR

6.4 Three LDR Sensor Values

The Output of Three LDR Sensor Values Are shown in Below Figure**.**

Fig.6.4: Three LDR Values

6.5 Output Voltage Values

As we can see, solar panels produce a significantly higher voltage (VOC) than the nominal voltage. The actually solar panel output voltage also changes with the sunlight the solar panels are exposed to.

Fig.6.5: Output Voltage Value

6.6 Testing and Monitoring Data of Solar Cleaner

The Real Time Of output voltage, current, and power from the panel and update it live on the **Thing speak** channel as shown below. Testing and monitoring data of solar panel cleaners typically include various parameters to assess their effectiveness and performance. Here are some key metrics commonly monitored:

Cleaning Efficiency: This metric evaluates how effectively the cleaner removes dirt, dust, and other debris from the surface of the solar panels. It may be measured by comparing the power output of the solar panels before and after cleaning.

Energy Production: Monitoring the energy production of the solar panels before and after cleaning can provide insights into the impact of cleanliness on performance. This data helps quantify the increase in energy generation resulting from cleaner panels.

Soiling Rate: Soiling rate refers to the rate at which dirt accumulates on the surface of the solar panels over time. Monitoring changes in soiling rate helps determine the frequency of cleaning required to maintain optimal performance.

Cleaning Frequency: Monitoring how often the solar panels are cleaned can help optimize cleaning schedules and resource allocation. It ensures that cleaning activities are performed at the right intervals to prevent significant losses in energy production due to soiling.

Water Consumption: For water-based cleaning systems, monitoring water consumption provides insights into the efficiency of the cleaning process and helps identify opportunities for water conservation.

Cleaning Time: Monitoring the time taken to clean the solar panels helps assess the efficiency of the cleaning equipment and the labor required for maintenance activities.

Weather Conditions: Monitoring weather conditions such as rainfall, humidity, and dust storms can help correlate changes in soiling rate with environmental factors. This data informs decision-making regarding cleaning schedules and strategies.

Remote Monitoring: Some solar panel cleaning systems offer remote monitoring capabilities, allowing operators to track cleaning activities, energy production, and system performance from a centralized dashboard or mobile app.

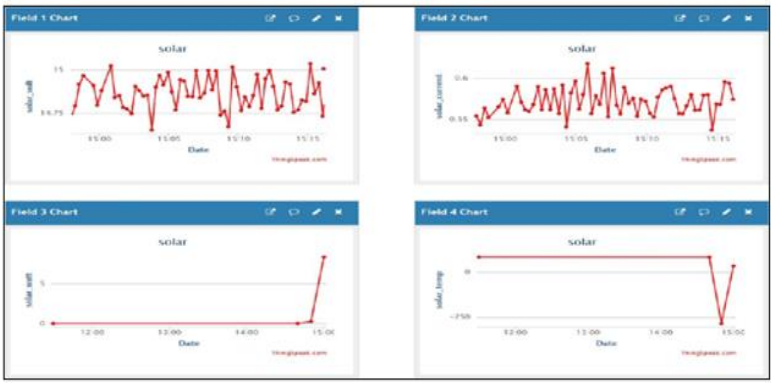


Fig.6.6: Manual Cleaner Data

CHAPTER- VII

CONCLUSION & FUTURE SCOPE

7.1 CONCLUSION

The IoT-based automated solar panel cleaning and monitoring system offers an efficient solution for enhancing the solar panel's performance. IoT technology enables the system to automate the cleaning process and monitor voltage and power generation in real-time. This reduces the man-hour, manpower requirement, maintenance cost, and likelihood of any faults or damages to the solar panel during the manual cleaning process. In traditional solar panel systems, manual cleaning methods and continuous monitoring options are limited.

Such an automation system can contribute meaningfully to the progression of renewable power generation by significantly improving the efficiency and longevity of solar panels. Thus, we can have sustainable and efficient energy systems in the country by integrating IoT-based automation systems.

7.2 FUTURE SCOPE

This project could be made even more innovative and capable of forecasting climate conditions as well as human behavior if we add artificial intelligence to our current technology. Since suggestions will be provided by the system, this intelligent system will also assist in understanding and repairing any defects. The current system is Wi-Fi compatible, but the GSM module allows for further customization. The GSM module necessitates the use of a sim card in order to communicate with the cloud. This method would be simple to understand and used by the entire town.

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