SOLAR BASED AUTOMATIC IRRIGATION SYSTEM

A Project
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ABSTRACT

The Solar-Powered Automatic Irrigation System integrates renewable energy and IoT-based automation to optimize water usage in agriculture. This system utilizes solar photovoltaic (PV) panels to generate electricity, powering a Node MCU microcontroller that automates the irrigation process based on real-time soil moisture data. The system includes soil moisture sensors to monitor water levels, a water pump for irrigation control, and an LCD display for real-time updates.With IoT integration, farmers can remotely monitor and control irrigation schedules via a mobile application or web interface. The Wi-Fi-enabled Node MCU allows seamless data transmission, ensuring precise water delivery and preventing over- or under-irrigation. By leveraging solar energy, the system reduces reliance on conventional electricity, making it ideal for off-grid and remote farming areas.This smart irrigation solution enhances water conservation, improves crop yield, and reduces manual labor. The integration of clean energy with advanced automation promotes sustainable agriculture, environmental conservation, and climate resilience. By minimizing water wastage and optimizing energy use, the system provides a cost-effective and eco-friendly alternative to traditional irrigation, making it suitable for both small and large-scale farming applications.

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CHAPTER - 1

INTRODUCTION

1.1 Overview

The Solar-Powered Automatic Irrigation System is an innovative solution that integrates renewable energy with smart farming techniques to optimize water usage. This system utilizes solar photovoltaic (PV) panels to power a NodeMCU microcontroller, which automates irrigation based on real-time soil moisture data. By leveraging IoT connectivity, farmers can remotely monitor and control the irrigation process via a mobile application or web interface. The system ensures efficient water management, reduces manual labor, and enhances crop productivity. Designed for off-grid and remote farming areas, it promotes sustainable agriculture by conserving water, minimizing energy consumption, and providing an eco-friendly alternative to traditional irrigation methods.

Existing surveys prove that farms and their unplanned irrigation methodologies are themajor contributors of water scarcity and approximately 25 to 30 percent of water is wasteddue to poor irrigation techniques. Methods like change in irrigation systems, land grading,placement of seed, and artificial drainage have been applied to agricultural fields toreduce water wastage. Water wastage can also be regulated by monitoring seasonal conditionsand field soil moisture values. By doing so, water consumption can be reduced by providingwater to the fields only when the soil moisture is below a defined threshold.

In this paper, we are proposing an automatic irrigation system which monitors the soilmoisture levels and the weather conditions periodically thereby automatically switch on thewater pump when the soil moisture is below a preset threshold and if the weather reports norain. The proposed system can be configured as either automatic or semi-automatic. In theautomatic mode, the system would automatically switch on the water pump when the soilmoisture is below a threshold, which varies with type of crop and the age of the crop. Whenthe soil moisture is above the threshold level, the motor gets switched off. In thesemiautomatic mode, the farmer would receive an LCD display alert about the fieldconditions. The motor will automatically turnoff when the soil moisture reaches the threshold level. The system also provides real timeupdates to the farmer about the weather and crop conditions so that the farmer can maintainan efficient future watering schedule.

The proposed irrigation system is powered with solar panel integrated with sun tracker. Asthese solar trackers generate more electricity than the traditional fixed solar panel due toincreased direct exposure to solar rays at every instant of day, its power efficiency can beimproved to a maximum of 45% depending on the geographic location of the trackingsystem.

1.2 Problem Statement

Irrigation is the most important cultural practice and most labor intensive task in daily agriculture sector. Knowing when and how much to water is two important aspects of irrigation. To do this automatically, sensors and methods are available to determine when plants may need water. Automation involves mechanism of all the industrial activities so as to improve the speed of production, reduction of cost, effective use of resources. With the growing requirement of electricity and concern for the environmental impact of fossil fuels, implementation of eco-friendly energy sources like solar power is rising. The efficiency of the single axis tracking system over that of the static panel is calculated to be 32.17% and the dual-axis tracking system over that of the static panel is calculated to be 81.68%. Due to seepage in drains, wastage of water is caused there is imbalance in distribution of labour. After growth of crops, water reaches the basins in disproportionate quantity thereby causing wastage of water, creation of problem of water logging.

1.3 Motivation

Before starting our project, we did research on different problems that are present in Agriculture land. During our research we found the struggle of farmers trying to figure out the solution to solve this problem for proper crops irrigation and energy source management. Thus we strike on the idea of developing a smart irrigation system based on solar power. This system would eradicate the problem faced by farmers to proper irrigation of farm land and increase in production of crops. We, being the student of Electronics and Communication Engineering Faculty, we thought that it would be our responsibility to develop such system which would solve the problem faced by farmers.

1.4 Objective

The objectives of this project are:

- To study about **Solar based Automatic Irrigation System**.
- To design and construct a **Solar based Automatic Irrigation System**.
- To start the motor by soil condition.
- To display the soil moisture level on display.
- To To utilize solar power for irrigation, minimizing reliance on conventional electricity and enabling off-grid operation.
- To fabricate a wireless irrigation using sensors and microcontroller.
- To save human energy and water consumption
- To put the whole system into action so that we can observe its practical effects and verify our work.

1.5 Methodology

Our methodologies for the project:

- Creating an idea for design and construction of an **Solar based Automatic Irrigation System**. And designing a block diagram & circuit diagram to know which components we need to construct it.
- Collecting all the components and programming the micro controller to control the whole system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

1.6 Work Flow Diagram

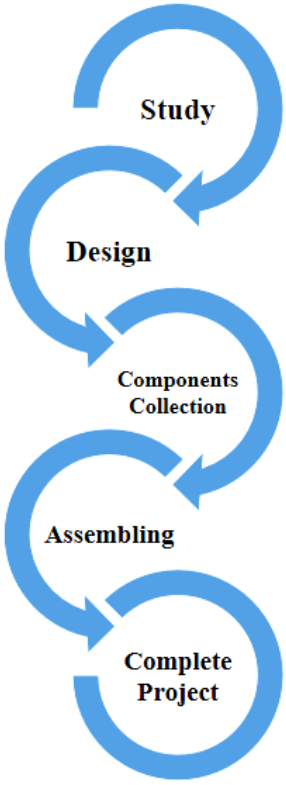


Figure 1.1: Working Flow Diagram

1.7 Research Outline

This project book consists of Six chapter. The first chapter contains the statement of the introduction,Overview, Problem Statement, Motivation,Work Flow Diagram, objectives of the study and Methodology. Chapter two contains system Literature Review details. Chapter three DiscussedinBlock Diagram,Circuit Diagram,Working principle and Cost analysis.Chapter Four describes the hardware implementation with component details and the software which we have used for our work. Chapter Five deals with the result Analysis,shows the complete prototype,Advantage, Application and Limitation of the project that we have built. In the final chapter, we have discussed the , Future Scope, conclusion of the project.

CHAPTER - 2

LITERATURE REVIEW

2.1 Introduction

In this chapter we discuss our system overview. In this paper they also work about**Solar based Automatic Irrigation System**. In below section we will describe some previous literature review. From previous literature we gather more knowledge to build this project and we successfully made it .

2.2 Literature Review

The paper presents a study on the Performance Analysis of Dual Axis Solar Tracking System Actuated Through Serial Manipulators, detailing the design and construction of a solar tracking system employing serial manipulators for actuation. Through experiments and simulations, the authors demonstrated its efficacy in enhancing solar energy harvesting, with improvements ranging from 19 to 28% in cloudy weather and 30 to 40.12% on sunny days. Advantages of using serial manipulators for solar tracking are discussed, along with construction and design constraints of the solar panel. The findings suggest significant performance enhancements, particularly in low solar irradiance areas or steep terrain, with potential applications in home heating and densely populated hilly regions [1].

The paper presents an Arduino-based automatic irrigation system that utilizes a microcontroller and GSM network for remote control and monitoring of irrigation processes, tank water levels, and rain detection via SMS commands. This system offers environmental and economic benefits by reducing water waste, labor costs, and effort associated with irrigation while providing a modern alternative to traditional methods. By integrating soil moisture sensors and microcontrollers, it automates irrigation processes and minimizes water usage, resulting in a 60% reduction compared to conventional methods. The system's ease of operation and remote accessibility make it a promising and sustainable solution for efficient irrigation practices[2].

The paper outlines the development of a Solar-Powered Smart Irrigation System (SPSIS) designed to mitigate water and electricity wastage in irrigation processes. Utilizing a

wireless sensor network and solar energy, the system operates either manually or via a mobile application, offering significant water and energy savings for farmers. Scalable by adjusting PV panel size, battery storage, and motor capacity, the SPSIS proves beneficial for sustainable agriculture in South Africa, enhancing efficiency even on overcast days. The well-organized document serves as a comprehensive guide for those interested in sustainable irrigation systems, providing detailed insights into its design, implementation, and testing[3].

This paper outlines the development of an innovative irrigation system powered by Arduino and solar technology. It aims to enhance efficiency, save resources, and increase crop quality by utilizing soil moisture sensors to regulate irrigation. The system is designed for areas with water scarcity and lack of electrical infrastructure, offering practical benefits for large-scale farming. The study suggests further enhancements like water level and noise sensors for optimized irrigation and security. Overall, it underscores the importance of renewable energy sources like solar power in improving agricultural practices and crop yields[4]

The paper reviews a Solar Powered Irrigation System utilizing Arduino UNO, aiming to enhance water usage efficiency and reduce waste through renewable resources and IoT technology. It employs sensors to monitor soil moisture and weather, controlled by an Arduino-based microcontroller for automated watering, capable of data transmission to a cloud server. Highlighting benefits like improved productivity and reduced human intervention, the system's use of solar power and IoT offers a sustainable solution for addressing water scarcity and food security concerns. Its adaptability to different crops and soil types further underscores its potential impact on enhancing food security while minimizing water wastage[5].

The Solar Based Automatic Irrigation System is a microcontrollerdriven solution harnessing solar power for ecofriendly irrigation in agriculture. It automates watering by detecting soil moisture levels, conserving energy and optimizing crop production. This costeffective system, adaptable to various crops and environments, utilizes renewable solar energy, offering farmers a sustainable and efficient irrigation alternative, ultimately enhancing crop yields while minimizing energy usage[6].

A microcontroller manages irrigation based on soil moisture levels, ensuring efficient water usage. Notably, the system is cost-effective and easily deployable, offering detailed insights into its components and functionality, promising improved crop yields and reduced water consumption for farmers worldwide[7].

The research proposes a system aimed at conserving water and energy in agriculture, specifically targeting the challenges faced by Indian farmers. Utilizing soil moisture sensors connected to an Arduino Uno, the system automatically controls irrigation by comparing sensed values with a predefined threshold, promoting water conservation. Integration of solar panels and a solar tracker enhances energy efficiency. The study emphasizes the importance of smart irrigation systems and IoT technology in improving water and energy management in agriculture, acknowledging challenges in testing and suggesting future applications of machine learning for crop data analysis. It underscores the significance of increasing agricultural production to meet the needs of India's growing population and cites related research, highlighting the importance of smart irrigation systems in resource optimization for Indian farming[8].

The paper describes an Automatic Solar Tracking System aimed at enhancing solar panel efficiency through singleaxis tracking to follow the sun's movement. This system utilizes semi-transparent silicon solar cells and includes a microcontroller and LDR sensors to control a DC motor, ensuring optimal solar panel orientation. It emphasizes the environmental benefits and importance of solar tracking for efficient energy collection, highlighting various tracker controllers. Overall, the system offers promise for improving solar energy efficiency, promoting sustainability, and addressing energy shortages[9].

The project proposes an innovative irrigation system that integrates sensor technology to optimize crop yields by considering factors like soil moisture and air humidity. Traditionally, farmers spend significant time irrigating without such considerations. However, this system relies on electrical energy for operation, and with increasing costs and depletion of conventional sources like fossil fuels, a photovoltaic (PV) system emerges as a sustainable alternative. The PV system directly harnesses solar energy, converting it into electric power to operate the water pump and sensors, typically comprising a solar panel, voltage stabilizer, and power inverter. While the PV panel initially produces direct current and voltage, which may not match the load circuit's requirements, the inclusion of a voltage stabilizer and power inverter ensures efficient operation of the system[10]

This project proposes an irrigation system integrated with sensor technology to enhance crop yields by optimizing water usage based on factors like soil moisture and air humidity. Unlike traditional methods that often overlook these factors, this system aims to improve efficiency. To address concerns about energy consumption and costs, the project suggests utilizing a photovoltaic (PV) system as a sustainable alternative to conventional energy sources like fossil fuels. The PV system directly harnesses solar energy to power the water pump and sensors, consisting of components such as solar panels, a voltage stabilizer, and a power inverter. These components ensure efficient operation by converting solar energy into usable electric power, enabling the irrigation system to function effectively while reducing reliance on non-renewable energy sources[11]

The paper discusses the advantages of employing a smart irrigation system with solar panels and sensor networks. It highlights the system's efficiency in managing irrigation in fields, gardens, and horticulture.The open-source design promotes recycling and reparability.The system is considered essential amidst the current global silicon shortage. Itmonitors various parameters to optimize irrigation, preventing over-irrigation. Over-irrigation is a common issue in agriculture due to unpredictable weather and lack of information.The paper references related research on automated trickle irrigation systems. It also mentions solar-powered fan caps for outdoor workers. Figure 5 depicts the user interface of the smart irrigation system.The conclusion emphasizes the eco-friendliness of the system.This is attributed to the use of solar panels and recycled lithium-ion batteries. The system ensures irrigation is provided in precise amounts required by the field. It minimizes water wastage and improves resource efficiency.The paper provides valuable insights into the benefits of integrating solar ener gy with smart irrigation technology. It addresses the specific needs of agriculture and horticulture. The system's ability to adapt to unpredictable weather conditions is highlighted. Its open-source nature encourages innovation and collaboration.The paper contributes to the discussion on sustainable agriculture practices. It underscores the importance of utilizing renewable energy sources in agricultural systems. Overall, the PDF offers valuable information for improving irrigation practices in agriculture and horticulture using solar energy and smart technology[12].

2.3 Summary

From the literature discussed above, we gained a lot of knowledge and we inspired to do this project. We were able to do it with everyone tireless work.

CHAPTER - 3

SYSTEM ARCHITECTURE

3.1 Introduction

The project objectives, methods, literature evaluation, and other details were all clarified in the preceding chapter. The block diagram, circuit diagram, Working principle, and final project instrument cost analysis will all be covered in this chapter.

3.2 Block Diagram

Here is the block diagram of the **Automatic Irrigation with Sun position Solar Tracking System**with all the essential components. All of the components are shown in below as a block in this diagram.Here we use Arduino Nano Micro-controller of our project. Other equipment's are attached with this micro-controller and work together for perform as our desire outcome.

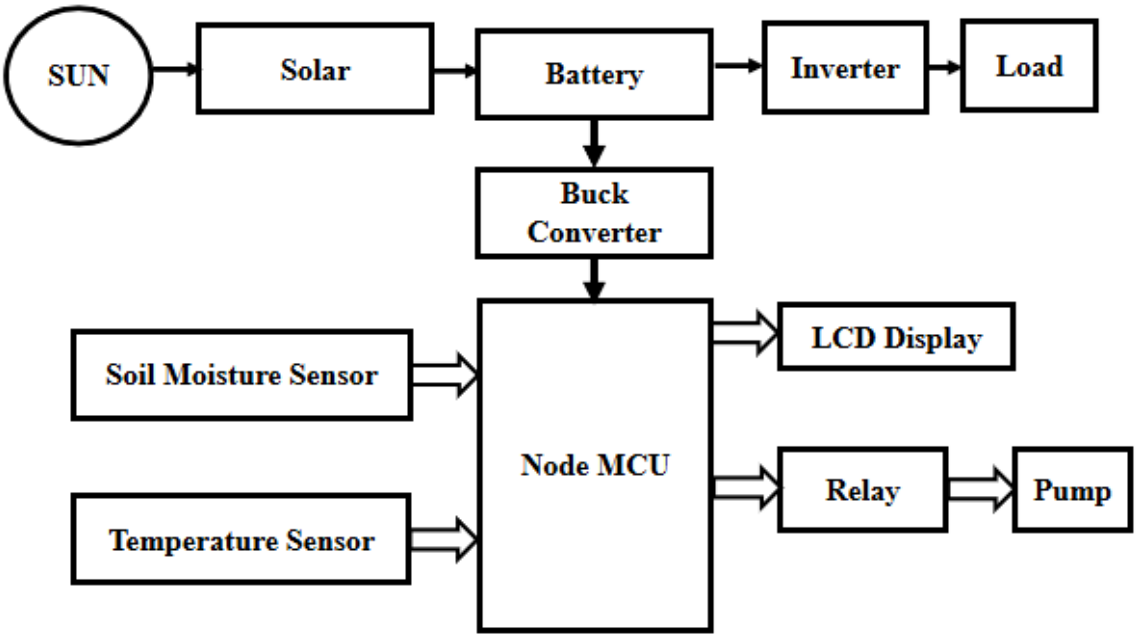


Figure 3.1: Block Diagram of Our System

3.3 Circuit Diagram

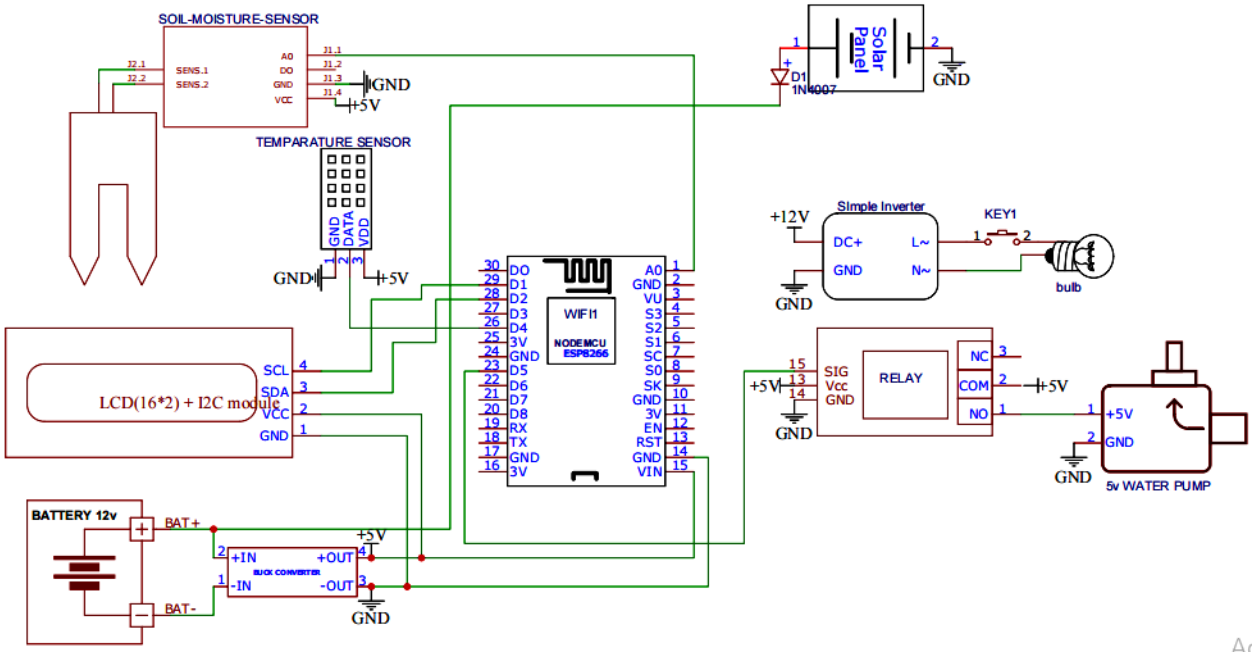


Figure 3.2: Schematic Diagram of Our System

3.4 Working Principle

The Solar-Based Automatic Irrigation System harnesses solar energy to power an automated irrigation process. A solar panel captures sunlight and converts it into electrical energy, which is stored in a battery. The buck converter regulates the voltage, ensuring a stable power supply for the system's components. The stored DC power is converted into AC using an inverter and a transformer, allowing it to run the AC load when necessary.

The NodeMCU microcontroller continuously monitors environmental conditions using a temperature sensor and a soil moisture sensor. When the soil moisture level drops below a set threshold, the NodeMCU activates a relay, which powers the pump motor to supply water to the field. The system efficiently manages power distribution, ensuring uninterrupted operation even in low-light conditions. Through IoT integration, users can remotely monitor and control the irrigation system, optimizing water usage and promoting sustainable agricultural practices.

3.5 Cost Analysis

Table 1:List of Component with Price

Sl. no	Particulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	Soil Moisture Sensor		1	300	300
2	Temperature Sensor	DHT 11	1	250	250
3	Node MCU	ESP8266	1	600	600
4	Solar panel	mini	1	350	350
5	LCD Display	16*2	1	450	450
6	Transfomer	220v 50Hz	1	350	350
7	Inverter Circuit		1	300	300
8	Battery	3.7V	3	100	300
9	Buck Converter	LM2596	1	200	200
10	Pump Motor	5V DC	1	250	250
11	Relay	1 channel	1	150	150
12	Others				600
				Total	4100/=

CHAPTER - 4

HARDWARE & SOFTWARE ANALYSIS

4.1 Introduction

In this section, we will discuss elaborately about "**Solar Based Automatic Irrigation System**" and the component description, features, working procedure of our all equipment.The system hardware fabricates composed of power unit, source unit, power store unite, and many more related components.

4.2 Components List

Hardware Part

1. Node MCU
2. Battery
3. Buck Converter
4. Solar Panel
5. Soil Moisture Sensor
6. Temperature Sensor
7. LCD Display
8. Transformer
9. Inverter Circuit
10. Pump Motor
11. Relay

Software Part

1. Arduino IDE
2. Easy EDA

4.3 Node MCU

Node MCU is an open-source firmware for which open-source prototyping board designs are available. The name "Node MCU" combines "node" and "MCU" (micro-controller unit). The term "Node MCU" strictly speaking refers to the firmware rather than the associated development kits. Both the firmware and prototyping board designs are open source. The firmware uses the Lua scripting language. The firmware is based on the eLua

project, and built on the Express if Non-OS SDK for ESP8266. It uses many open source projects, such as leucosin and SPIFFS. Due to resource constraints, users need to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also been implemented.

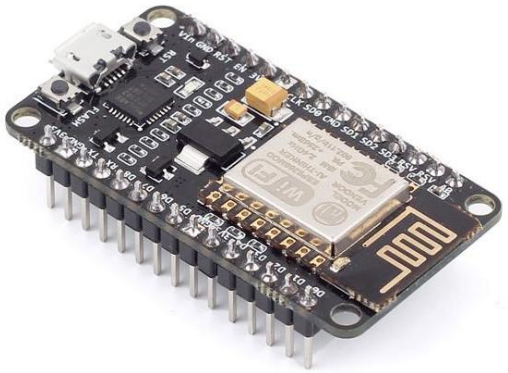


Figure 4.1: Node MCU

The prototyping hardware typically used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allows for easy prototyping on breadboards. The design was initially was based on the ESP-12 module of the ESP8266, which is a Wi-Fi SoC integrated with a TensilicaXtensa LX106 core, widely used in IoT applications.

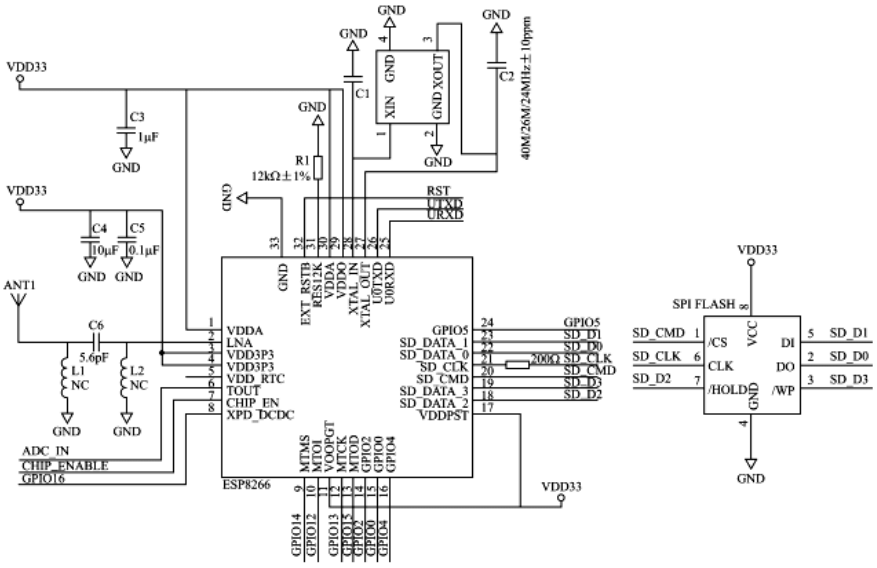


Figure 4.2: Node MCU Schematic Diagram

This an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Express if Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Luascripting language. It is based on the eLua project, and built on the Espress if Non-OS SDK for ESP8266. Node MCU was created shortly after the ESP8266 came out. On December 30, 2013, Espressif Systems began production of the ESP8266. The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications (see related projects). Node MCU started on 13 Oct 2014, when Hong committed the first file of nodemcu-firmware to GitHub. Two months later, the project expanded to include an open-hardware platform when developer Huang R committed the gerber file of an ESP8266 board, named devkit v0.9. Later that month, Tuan PM ported MQTT client library from Contiki to the ESP8266 SoC platform, and committed to Node MCU project, then Node MCU was able to support the MQTT IoT protocol, using Lua to access the MQTT broker. Another important update was made on 30 Jan 2015, when Devsaurus ported the u8glibto Node MCU project,[15] enabling Node MCU to easily drive LCD, Screen, OLED, even VGA displays. In summer 2015 the creators abandoned the firmware project and a group of independent contributors took over. By summer 2016 the Node MCU included more than 40 different modules. Due to resource constraints users need to select the modules relevant for their project and build a firmware tailored to their needs.

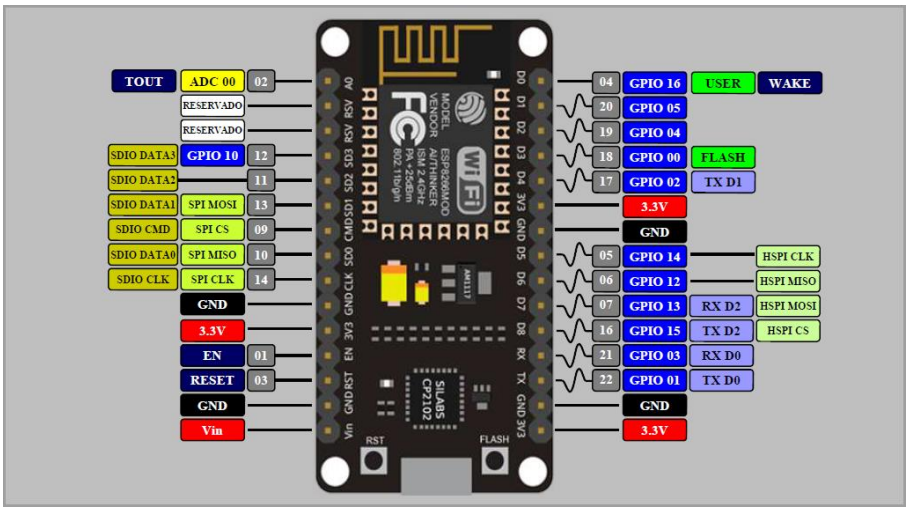


Figure 4.3: Node MCU Pin Out

Node MCU V3 ESP8266 ESP-12E is Wi-Fi development board that helps you to prototype your IoT product with few Lua script lines, or through Arduino IDE. The board is based on ESP8266 ESP-12E variant, unlike other ESP-12E, you won't need to buy a separate breakout board, USB to serial adapter, or even solder it to a PCB to get started, you will only need a USB cable (Micro USB).

Features

- Communication interface voltage: 3.3V.
- Antenna type: Built-in PCB antenna is available.
- Wireless 802.11 b/g/n standard
- WiFi at 2.4GHz, support WPA / WPA2 security mode
- Support STA/AP/STA + AP three operating modes
- Built-in TCP/IP protocol stack to support multiple TCP Client connections (5 MAX)
- D0 ~ D8, SD1 ~ SD3: used as GPIO, PWM, IIC, etc., port driver capability 15mA
- AD0: 1 channel ADC
- Power input: 4.5V ~ 9V (10VMAX), USB-powered
- Current: continuous transmission: ≈70mA (200mA MAX), Standby: <200uA
- Transfer rate: 110-460800bps
- Support UART / GPIO data communication interface
- Remote firmware upgrade (OTA)
- Flash size: 4MByte.

4.4 Solar Panel

This solar panel is used to make it expose towards sunlight and to show that harvesting of energy occurs.A solar panel is a technology that uses the photoelectric effect to transfer charge carriers between two separate layers. The separated charges create a volt- age difference. The two voltage levels can be connected to an electrical circuit to generate a direct current through the circuit.Concentrated solar panels have optics that capture sunlight directly, so the solar panel must be positioned at the correct angle to capture the energy. The concentrated solar energy systems are equipped with tracking systems, as the systems cannot generate energy if they are not correctly aligned with the sun. The voltage of the

solar panel may not be constant at all times since the light intensity of the sun changes throughout day.

$$P = V * I$$



Figure 4.4: Solar Panel

Where,

- ✓ P as power (W)
- ✓ V as voltage (V)
- ✓ I as current (A)

According to Lambert's cosine law, the radiant energy measurement on a Lam- bert reflecting surface is directly proportional to the cosine of the angle formed by the measurement point and the surface normal. Accordingly, the illuminance incident on a surface varies as the cosine of the angle of incidence. At an oblique angle, the measurement area perpendicular to the incident light beam is much.Smaller, so the energy is distributed over a larger area than when the incident radiation is perpendicular to the surface. Assuming a fixed surface, the amount of exposed energy decreases significantly as the source approaches the grazing incidence. Grazing incidence refers to situations where the irradiance or illumination is almost parallel to the incident surface, i.e. the angle of incidence is very close to 90 degrees .

4.5 Battery

Lithium batteries are primary batteries that have metallic lithium as an anode. These types of batteries are also referred to as lithium-metal batteries. They stand apart from other batteries in their high charge density and high cost per unit. Depending on the design and

chemical compounds used, lithium cells can produce voltages from 1.5 V (comparable to a zinc–carbon or alkaline battery) to about 3.7 V.

Disposable primary lithium batteries must be distinguished from secondary lithium-ion or a lithium-polymer,[1] which are rechargeable batteries. Lithium is especially useful, because its ions can be arranged to move between the anode and the cathode, using an intercalated lithium compound as the cathode material but without using lithium metal as the anode material. Pure lithium will instantly react with water, or even moisture in the air; the lithium in lithium ion batteries is in a less reactive compound.



Figure 4.5: 3.7V Battery

Lithium batteries are widely used in portable consumer electronic devices. The term "lithium battery" refers to a family of different lithium-metal chemistry, comprising many types of cathodes and electrolytes but all with metallic lithium as the anode. The battery requires from 0.15 to 0.3 kg of lithium per kWh. As designed these primary systems use a charged cathode, that being an electro-active material with crystallographic vacancies that are filled gradually during discharge.

Product Specification

Table 2: Battery Specification

Voltage	3.7 V
Product Type	Lithium-Ion
Battery Capacity	2200mAh
Weight	45 g

Model Number	ICR 18650

4.6 Buck Converter

A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while drawing less average current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) typically containing at least two semiconductors (a diode and a transistor, although modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage element, a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter). It is called a buck converter because the voltage across the inductor "bucks" or opposes the supply voltage.



Figure 4.6: DC -DC Buck Converter

DC-DC Buck Converter Step Down Module LM2596 Power Supply is a step-down(buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. The LM2596 series operates at a switching frequency of 150kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators.

Specifications of DC-DC Buck Converter Step Down Module LM2596 Power Supply

- Conversion efficiency: 92%(highest)
- Switching frequency: 150KHz
- Output ripple: 30mA9maximum)
- Load Regulation: ± 0.5%
- Voltage Regulation: ± 0.5%
- Dynamic Response speed: 5% 200uS
- Input voltage:4.75-35V
- Output voltage:1.25-26V(Adjustable)
- Switching Frequency: 150KHz
- Rectifier: Non-Synchronous Rectification
- Module Properties: Non-isolated step-down module (buck)
- Short Circuit Protection: Current limiting, since the recovery
- Operating Temperature: Industrial grade (-40 to +85) (output power 10W or less)

4.7LCD Display

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



Figure 4.7: 16*2 LCD Display

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

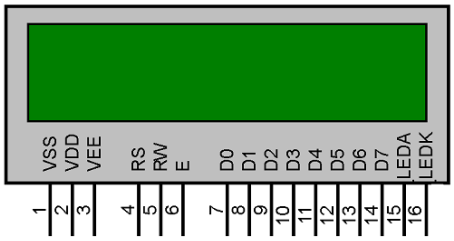


Figure 4.8: Pin out of 16*2 LCD Display

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

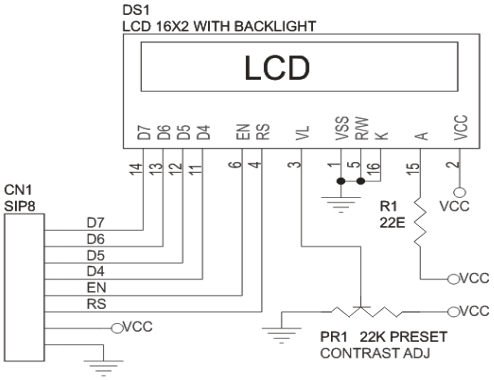


Figure 4.9: 16*2 LCD Display interfacing with Arduino

Feature

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers

4.8 Inverter Circuit

An inverter circuit converts DC (Direct Current) power from sources like batteries or solar panels into AC (Alternating Current) power, which is suitable for powering household appliances and electrical devices. The inverter works by switching the DC input on and off rapidly using transistors or MOSFETs, creating a pulsed DC output. This output is then

smoothed using filters to produce a stable AC waveform. Inverters are crucial for renewable energy systems, enabling the use of DC-based solar power or stored battery energy for devices that require AC, like lights, fans, and home appliances. Some inverters also include voltage regulation and protection features.



Figure 4.10: Inverter Circuit

4.9 Transformer

A transformer is an electrical device used to change the value of an alternating voltage. Transformers are widely used in electrical work. They are encountered daily, in industrial, commercial and domestic situations. They vary in size from miniature units used in electronics to huge units used in power stations. The efficient transmission and distribution of electricity throughout the country would be impossible without the use of power transformers. Center Tapped Step Down Transformer is a general purpose chassis mounting mains transformer. Transformer has 230V primary winding and center tapped secondary winding. The transformer has flying colored insulated connecting leads (Approx 100 mm long). The Transformer act as step down transformer reducing AC - 230V to AC - 12V. The Transformer gives outputs of 12V, 12V and 0V.



Figure 4.11: Transformer

The Transformer's construction is written below with details of Solid Core and Winding. The transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the secondary winding. This varying magnetic flux induces a varying electromotive force (E.M.F) or voltage in the secondary winding. The transformer has cores made of high permeability silicon steel. The steel has a permeability many times that of free space and the core thus serves to greatly reduce the magnetizing current and confine the flux to a path which closely couples the winding.

Full Wave Bridge Rectifier

This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop “bridge” configuration to produce the desired output.The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below. The filtered full wave rectifier is created from the FWR by adding a capacitor across the output.

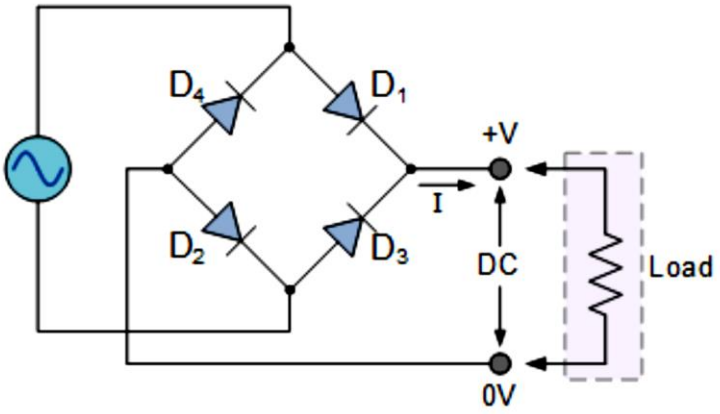


Figure 4.12: Full Wave Bridge Rectifier

The four diodes label led D1 to D4 are arranged in “series pairs” with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

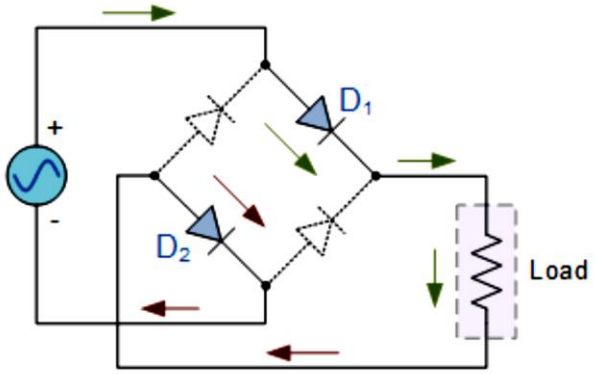


Figure 4.13: Positive Half Cycle of Full Wave Bridge Rectifier

The Positive half Cycle: During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch “OFF” as they are now reverse biased. The current flowing through the load is the same direction as before.

4.10 Soil Moisture Sensor

This soil moisture sensor module is used to detect the moisture of the soil. It measures the volumetric content of water inside the soil and gives us the moisture level as output. The module has both digital and analog outputs and a potentiometer to adjust the threshold level.

Moisture Sensor Module Pinout Configuration

Table 3: Pin Configuration of Soil Moisture Sensor

Pin Name	Description
VCC	The Vcc pin powers the module, typically with +5V
GND	Power Supply Ground
DO	Digital Out Pin for Digital Output.
AO	Analog Out Pin for Analog Output

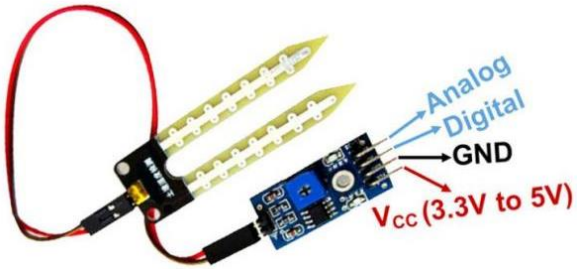


Figure 4.14: Soil Moisture Sensor

Moisture Sensor Module Features & Specifications

- Operating Voltage: 3.3V to 5V DC
- Operating Current: 15mA
- Output Digital - 0V to 5V, Adjustable trigger level from preset
- Output Analog - 0V to 5V based on infrared radiation from fire flame falling on the sensor
- LEDs indicating output and power
- PCB Size: 3.2cm x 1.4cm
- LM393 based design
- Easy to use with Microcontrollers or even with normal Digital/Analog IC
- Small, cheap and easily available

4.11 Pump Motor

This is a low cost, small size Submersible Pump Motor which can be operated from a 2.5 ~ 6V power supply. It can take up to 120 liters per hour with very low current consumption of 220mA. Just connect tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise.



Figure 4.15: Pump Motor

Feature

- Operating Current : 130 ~ 220mA
- Flow Rate : 80 ~ 120 L/H
- Maximum Lift : 40 ~ 110 mm
- Continuous Working Life : 500 hours
- Driving Mode : DC, Magnetic Driving
- Material : Engineering Plastic
- Outlet Outside Diameter : 7.5 mm
- Outlet Inside Diameter : 5 mm

4.12 Temperature Sensor

The DHT11 is a basic, ultra-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.

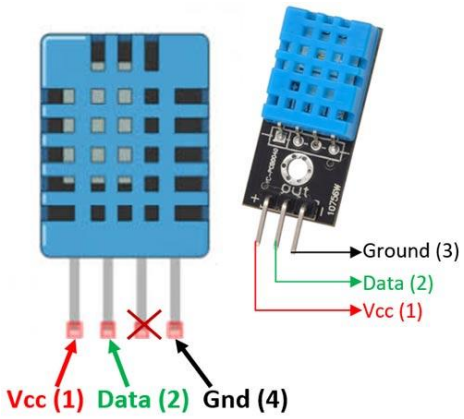


Figure 4.16: DHT11 Temperature Sensor

DHT11 Specifications

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±1°C and ±1%

4.13 Relay

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.



Figure 4.17: Relay

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts.Magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands.The relay module is the one in the figure below.

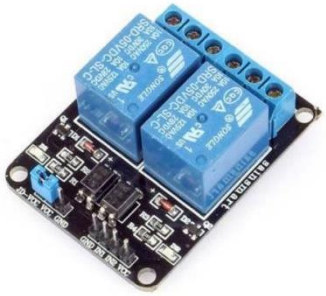


Figure 4.18: Relay Module.

This module has two channels (those blue cubes). There are other varieties with one, four and eight channels.

Main's voltage connections.

In relation to mains voltage, relays have 3 possible connections:

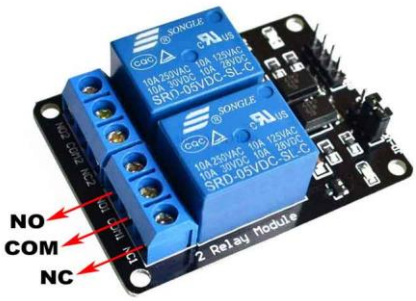


Figure 4.19: Main's voltage connections.

COM: common pin

NO (Normally Open): there is no contact between the common pin and the normally open pin. So, when you trigger the relay, it connects to the COM pin and supply is provided to a load

NC (Normally Closed): there is contact between the common pin and the normally closed pin. There is always connection between the COM and NC pins, even when the relay is turned off. When you trigger the relay, the circuit is opened and there is no supply provided to a load.



Figure 4.20: Voltage Connections

Pin wiring

The connections between the relay module and the Arduino are really simple:

GND: goes to ground

IN: controls the first relay (it will be connected to an Arduino digital pin)

IN2: controls the second relay (it should be connected to an Arduino digital pin if you are using this second relay. Otherwise, you don't need to connect it)

VCC: goes to 5V

SOFTWARE

4.14 Arduino IDE

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

Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and programs the microcontroller through the ICSP (In Circuit Serial Programming) header. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. On Rev2 or later boards: there is a resistor that pulling the

8U2/16U2 HWB line to ground, making it easier to put into DFU mode.The Arduino UNO is one of the latest digital microcontroller units and has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .in file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board.

The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial Communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Lab to compile programs, and for uploading the programs it uses argued. As the Arduino platform uses Atmel microcontrollers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.

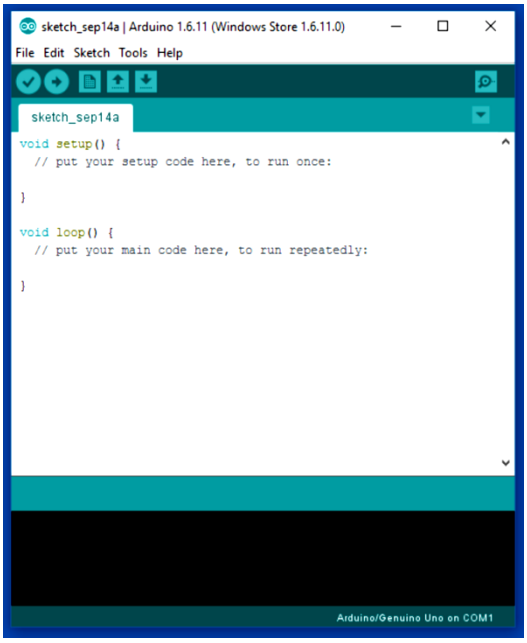


Figure 4.21: Arduino Software Interface IDE

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

Writing Sketches

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

Sketchbook

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences

dialog.Beginning with version 1.0, files are saved with a .ino file extension. Previous versions use the .pde extension. You may still open .pde named files in version 1.0 and later, the software will automatically rename the extension to .ino.

Tabs, Multiple Files, and Compilation

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

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

Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, bootloaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory.

For details on creating packages for third-party hardware, see the Arduino IDE 1.5 3rd party Hardware specification.

Serial Monitor

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial.begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board.

4.15 Easy EDA

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

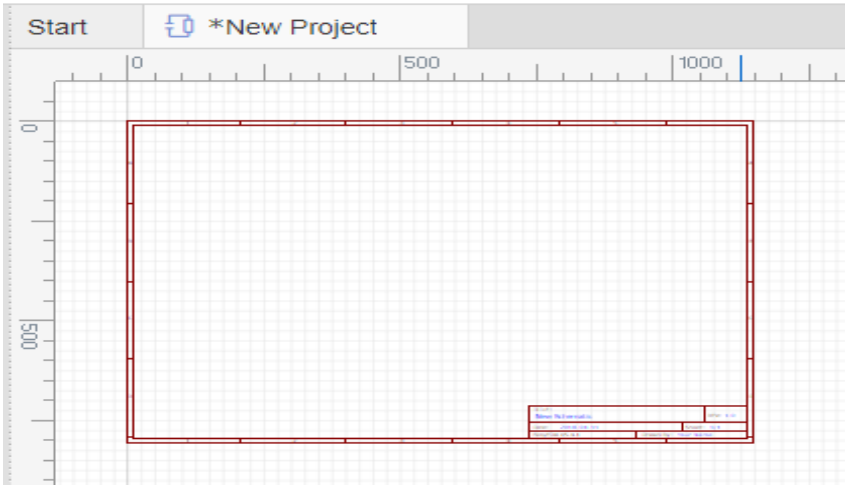


Figure4.22:Easy EDA Software Interface

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

CHAPTER - 5

RESULT ANALYSIS

5.1 Result Analysis

After finally completing this project, we ran it & we observed the output of this project. We can see that it is working well as expected. After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

- Finally, we have completed our project successfully & check our project its run accurately according to our objective.
- At first, we start our system.
- Following are the outputs of our project
- If moisture falls below the set threshold, the Node MCU triggers the Relay, which powers the pump motor to irrigate the field.
- Power is managed efficiently with a battery to inverter to AC load setup, ensuring uninterrupted operation of the irrigation system, even in low light conditions.
- An LCD display provides real-time information on soil moisture levels, Temperature and system performance.

5.2 Complete Project Prototype

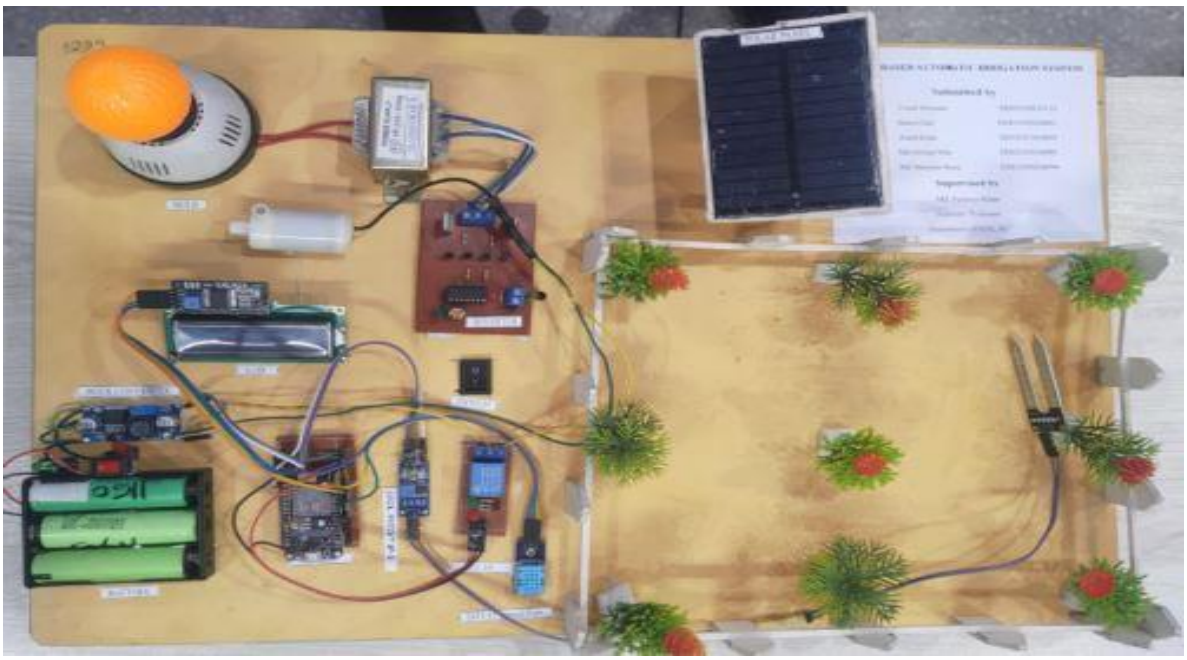


Figure 5.1:Our Final project

5.3 Advantage

There are many advantages of the project. Some of these are given below:

- The whole system is automatic system.
- Able to detect water level in field.
- Easy to use.
- Water Conservation
- Real-Time Data give
- Lowered Operation Costs
- Efficient and Saves Time
- Reduce soil erosion and nutrient leaching
- Reduces Carbon Footprint
- Enviromentally Friendly
- User-friendly

5.4 Limitation

Through the project has many advantages it has also some limitation, they are given below:

- The system needs to be more efficient to produce more energy.
- On rainy days, some problems may occur which can hamper energy production.
- Used cheap Chinese products for the prototype so there's some processing delay present in the circuit
- This project can now be only used for small scale purposes.\
- To get all notification mobile and project must be connected with the internet.

5.5 Application

This project has applications in many fields due its necessity. We have selected a few of them and they are given below:

- In rural area
- For agriculture use
- In Indoor Garden
- In Flower Garden

5.6 Discussion

The safety of the operator can be improved by providing alternatives to the existing design of the stand up forklift trucks. One such alternative is to provide a door to protect the operator. Design changes had to be made to prevent accidents and to protect the operator in case of an accident. In the electronic forklift, by using the electronic control system, the operator doesn't face any difficulties in the work envelope. Regular preventative maintenance is required.

The Solar-Based Automatic Irrigation System successfully integrates renewable energy with smart automation to optimize irrigation. By utilizing solar power, it offers a sustainable, off-grid solution for efficient water management in agriculture. The system's ability to adjust irrigation based on soil moisture levels ensures minimal water wastage, improving crop yield. IoT integration allows for remote monitoring, making it easier for farmers to control and optimize irrigation schedules. The battery, buck converter, and inverter work together to ensure reliable power, even in low light conditions. Overall, this project demonstrates the potential of combining renewable energy and automation to create cost-effective, sustainable farming solutions.

CHAPTER - 6

CONCLUSION

6.1 Conclusion

In conclusion, the Automatic Irrigation with Sun Position Solar Tracking System presents an innovative and sustainable solution for modern irrigation needs. By combining solar energy with smart automation, it ensures optimal power efficiency and water conservation. The use of LDR sensors for dynamic sun tracking maximizes the energy capture of the solar panel, while the soil moisture sensor ensures that irrigation only occurs when necessary, preventing overwatering. The battery-to-inverter setup guarantees consistent system operation, even during periods of low sunlight, ensuring reliability. The integration of real-time monitoring through an LCD display further enhances the system's ease of use and maintenance. This project not only reduces dependency on traditional power sources and water usage but also promotes environmental sustainability. It offers a cost-effective, low-maintenance solution suitable for both small-scale and large-scale agricultural or gardening operations, ultimately contributing to more efficient, eco-friendly farming practices.

6.2 Future Work

As we have already discussed about the advantages, applications of our project so definitely there's room for improvement. Some of these are listed below:

- In future development this project can be develop by more sensor and alarm System
- In future, I will try it to apply in real field.
- In Future develop add extra power system.
- In the future, add a GSM module to send an SMS alert system.
- In future we will add camera monitoring system in land.

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APPENDIX

Programming Code:

```
#include <DHT.h>
#define DHTPIN 2              // DHT data pin connected to digital pin 2
#define DHTTYPE DHT11        // Change to DHT22 if you're using that
#define SOIL_MOISTURE_PIN A0
#define RELAY_PIN 7

DHT dht(DHTPIN, DHTTYPE);

int soilMoistureValue = 0;
int moistureThreshold = 400;     // Adjust this value based on soil and sensor
unsigned long lastPrint = 0;

void setup() {
  Serial.begin(9600);
  pinMode(RELAY_PIN, OUTPUT);
  digitalWrite(RELAY_PIN, HIGH);          // OFF state for active LOW relay
  dht.begin();
}
void loop() {

 soilMoistureValue =  analogRead(SOIL_MOISTURE_PIN);
  float temperature =  dht.readTemperature();


  Serial.print("Soil Moisture: ");
  Serial.print(soilMoistureValue);
  Serial.print(" | Temp: ");
  Serial.println(temperature);


  if (soilMoistureValue > moistureThreshold) {
    digitalWrite(RELAY_PIN, LOW); // Turn ON pump
    Serial.println("Irrigation ON");
  } else {
    digitalWrite(RELAY_PIN, HIGH); // Turn OFF pump
    Serial.println("Irrigation OFF");
  }


  delay(5000); // Wait 5 seconds before next reading
}
```