Smart Irrigation System

Electronics Project Report

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We are extremely thankful to all of them for their invaluable contributions, which were instrumental in the successful realization of this project. Their mentorship has left a lasting impact on our academic journey.

— *Team Electropookies*

Contents

1 Introduction

1.1 What is Smart Irrigation?

Smart irrigation means using technology to automatically water plants only when they actually need it. It uses things like sensors and small computers (like Arduino) to check if the soil is dry and then turns the water on or off. This helps save water and makes watering more efficient.

1.2 Why it Matters?

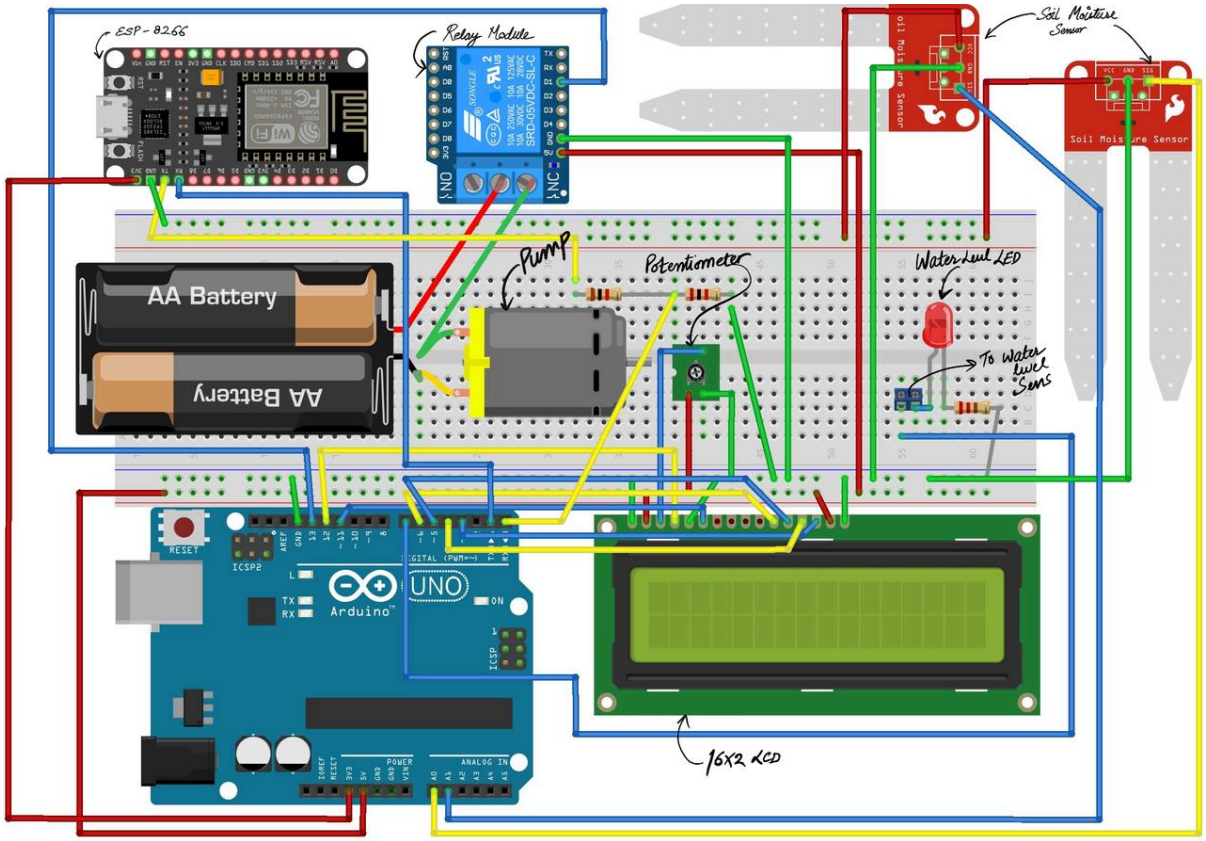
- **Water Conservation** — Uses only the needed amount of water, reducing waste.
- **Cost Savings** — Lowers water and energy bills over time.
- **Environmental Protection** — Minimizes runoff and preserves natural resources.
- **Better Crop Yields** — Provides optimal watering for healthier plants.
- **Automation & Control** — Remote access and easy scheduling via smart devices.

1.3 Goals of Our Project

- **Efficient Water Usage** — Implement smart irrigation to minimize water wastage and optimize consumption.
- **Support Sustainable Agriculture** — Promote eco-friendly farming practices through precision watering.
- **Enhance Crop Productivity** — Improve plant health and yield by providing the right amount of water at the right time.
- **Reduce Operational Costs** — Lower expenses related to water usage, labor, and energy through automation.
- **Leverage Smart Technology** — Use sensors, IoT, and data analytics to make real-time, informed irrigation decisions.

2 System Design

2.1 Circuit used



2.2 Components Used

The smart irrigation system uses the following key components:

- Arduino Uno
- Relay Module
- Soil Moisture Sensor
- 16x2 LED Display
- ESP8266

3 Principle of Working

3.1 Working

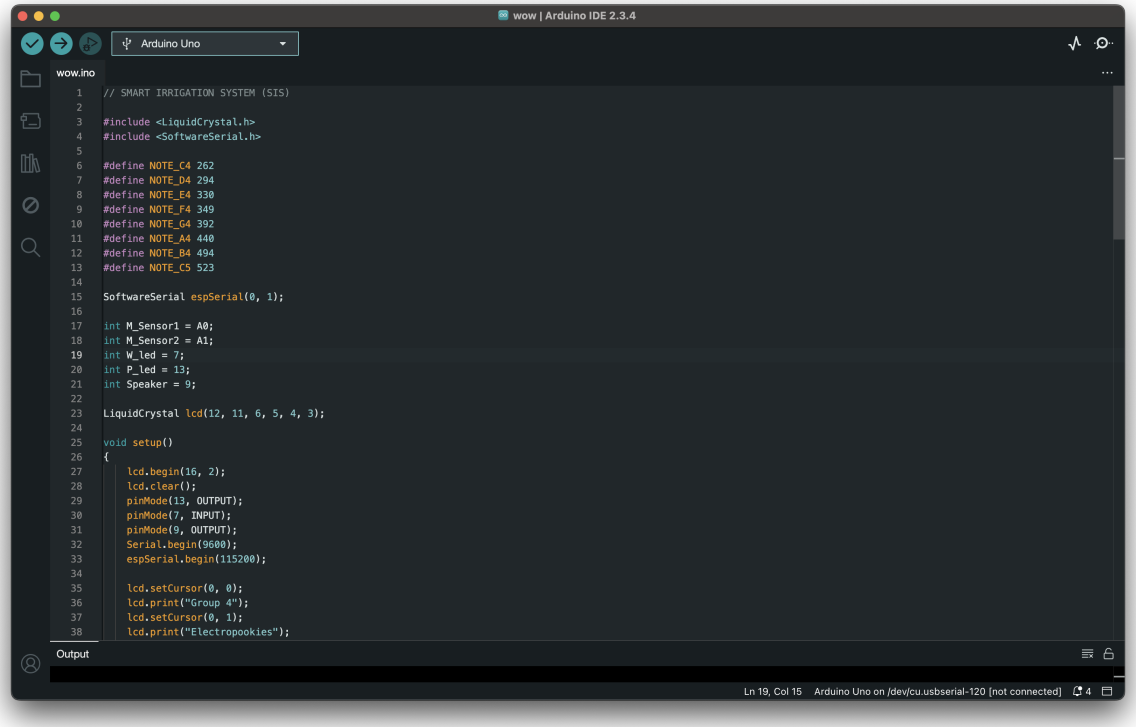
The system itself is composed of several parts, each with its own task:

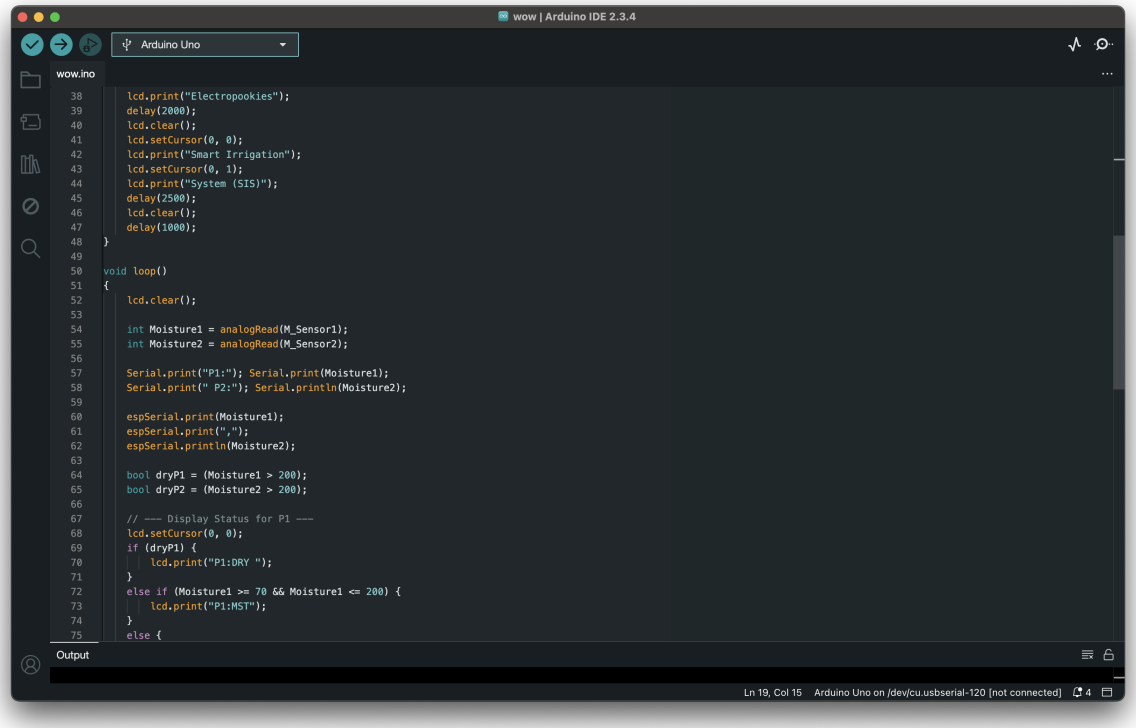
- The system begins by continuously monitoring soil moisture levels using a soil moisture sensor.
- This sensor measures the electrical resistance of the soil — higher resistance indicates drier soil.
- The sensor sends real-time moisture data to a microcontroller (e.g., Arduino Uno).
- The microcontroller analyzes the data and checks if the moisture level is below a set threshold.
- If the soil is too dry, the microcontroller activates a relay module.
- The relay module, in turn, powers the water pump, allowing water to be delivered to the plants.
- As the soil absorbs the water and moisture level rises, the sensor detects the change.
- Once the soil reaches the required moisture level, the microcontroller automatically switches off the pump.
- This cycle helps in efficient water usage, prevents overwatering, and ensures plant health.

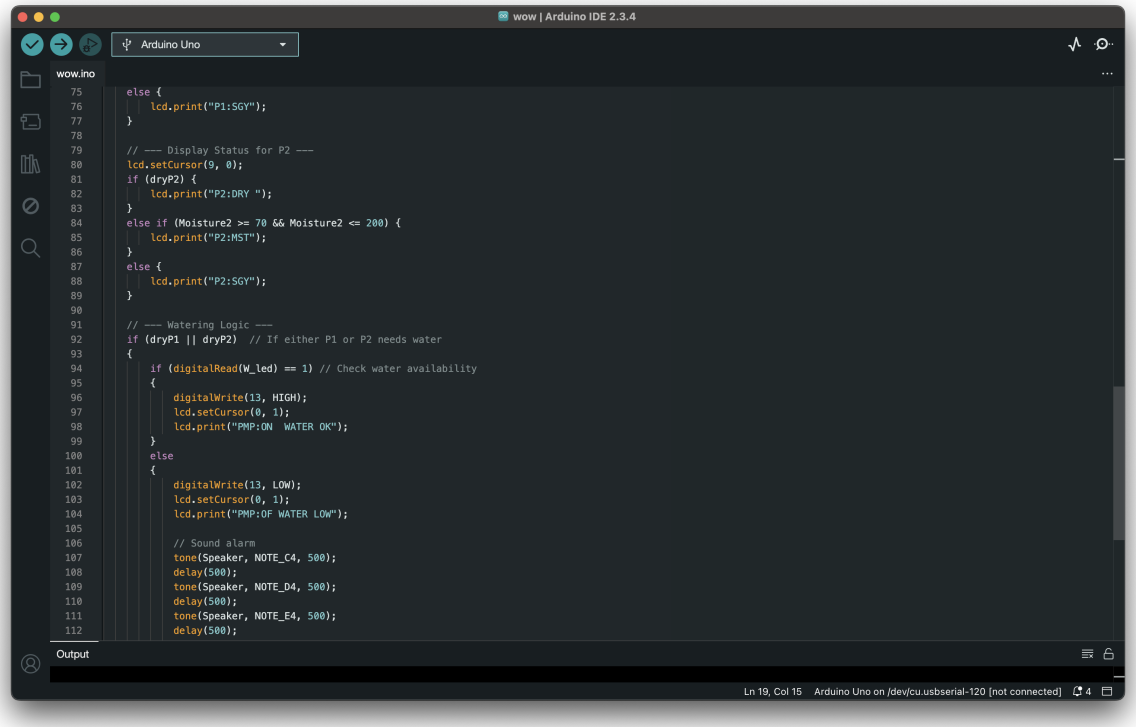
4 Code and Logic

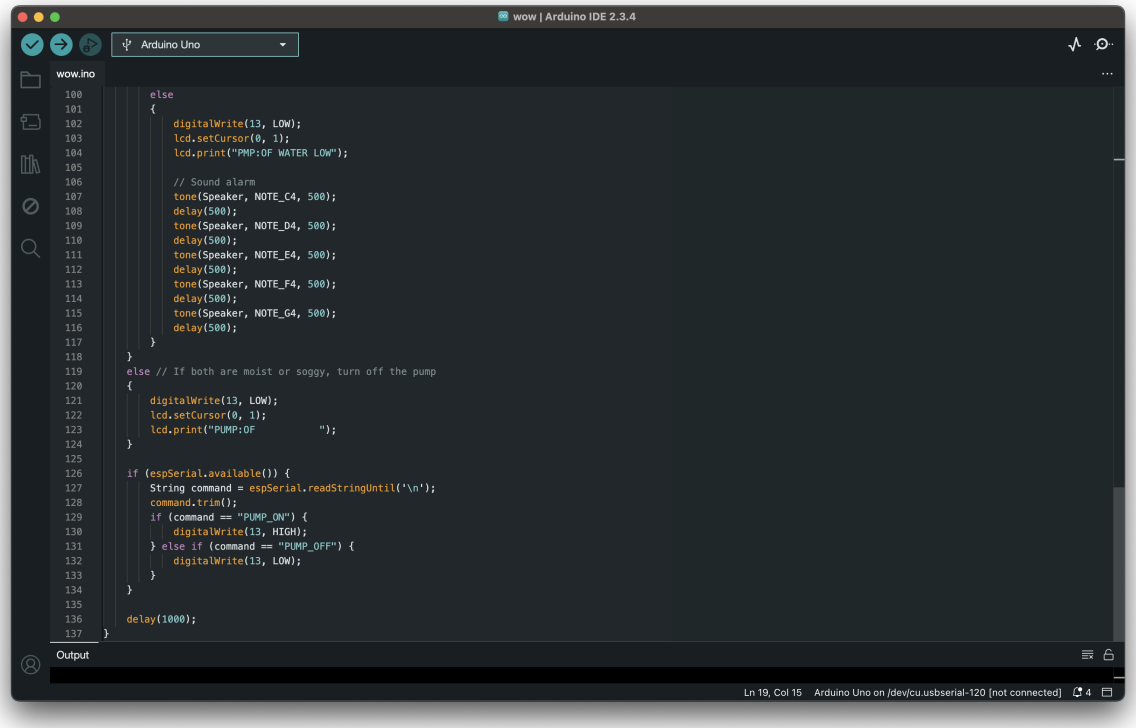
4.1 Code

Here below is the code for Smart Irrigation System:






wow | Arduino IDE 2.3.4
Arduino Uno
wow.ino
else {
lcd.print("P1:SGY");
}
// --- Display Status for P2 ---
lcd.setCursor(9, 0);
if (dryP2) {
lcd.print("P2:DRY ");
}
else if (Moisture2 >= 70 && Moisture2 <= 200) {
lcd.print("P2:MST");
}
else {
lcd.print("P2:SGY");
}
// --- Watering Logic ---
if (dryP1 || dryP2) // If either P1 or P2 needs water
{
if (digitalRead(W_led) == 1) // Check water availability
{
digitalWrite(13, HIGH);
lcd.setCursor(0, 1);
lcd.print("PMP:ON WATER OK");
}
else
{
digitalWrite(13, LOW);
lcd.setCursor(0, 1);
lcd.print("PMP:OF WATER LOW");
// Sound alarm
tone(Speaker, NOTE_C4, 500);
delay(500);
tone(Speaker, NOTE_D4, 500);
delay(500);
tone(Speaker, NOTE_E4, 500);
delay(500);
Output
Ln 19, Col 15 Arduino Uno on /dev/cu.usbserial-120 [not connected] 4


wow | Arduino IDE 2.3.4
Arduino Uno
wow.ino
else
{
digitalWrite(13, LOW);
lcd.setCursor(0, 1);
lcd.print("PMP:OF WATER LOW");
// Sound alarm
tone(Speaker, NOTE_C4, 500);
delay(500);
tone(Speaker, NOTE_D4, 500);
delay(500);
tone(Speaker, NOTE_E4, 500);
delay(500);
tone(Speaker, NOTE_F4, 500);
delay(500);
tone(Speaker, NOTE_G4, 500);
delay(500);
}
}
else // If both are moist or soggy, turn off the pump
{
digitalWrite(13, LOW);
lcd.setCursor(0, 1);
lcd.print("PUMP:OF ");
}
if (espSerial.available()) {
String command = espSerial.readStringUntil('\n');
command.trim();
if (command == "PUMP_ON") {
digitalWrite(13, HIGH);
} else if (command == "PUMP_OFF") {
digitalWrite(13, LOW);
}
}
delay(1000);
}
Output
Ln 19, Col 15 Arduino Uno on /dev/cu.usbserial-120 [not connected] 4

5 Discussion

The efficiency of the current model can be significantly improved by incorporating solar panels as the primary power source. Additionally, replacing the motorized pumping mechanism with a gravity-fed system—by positioning the water reservoir at an elevated height—would reduce power consumption. In such a setup, water flow can be effectively controlled using solenoidal valves, further simplifying the design.

During the course of development, it was identified that the ESP8266 microcontroller could serve as a more efficient alternative to the Arduino board. The ESP8266 offers several advantages, including a smaller physical footprint, lower power consumption, a sufficient number of analog and digital pins to support the circuit, and built-in Wi-Fi capabilities, making it well-suited for IoT applications.

However, the initial prototype was developed using an Arduino-based design, which posed certain limitations. Transitioning to the ESP8266 would have required significant hardware and software modifications—an undertaking that was not feasible within the limited timeframe available for the project.

6 Precautions

- Proper Sensor Placement : Place soil moisture sensors at appropriate depths and locations to get accurate readings.
- Waterproofing Electronics : Ensure all electronic components (Arduino, relays, connections) are properly insulated or enclosed to protect from water damage.
- Stable Power Supply : Use a stable and uninterrupted power source to avoid system malfunction.
- Test the System Periodically : Run checks to ensure that sensors, relays, and pumps are functioning correctly.

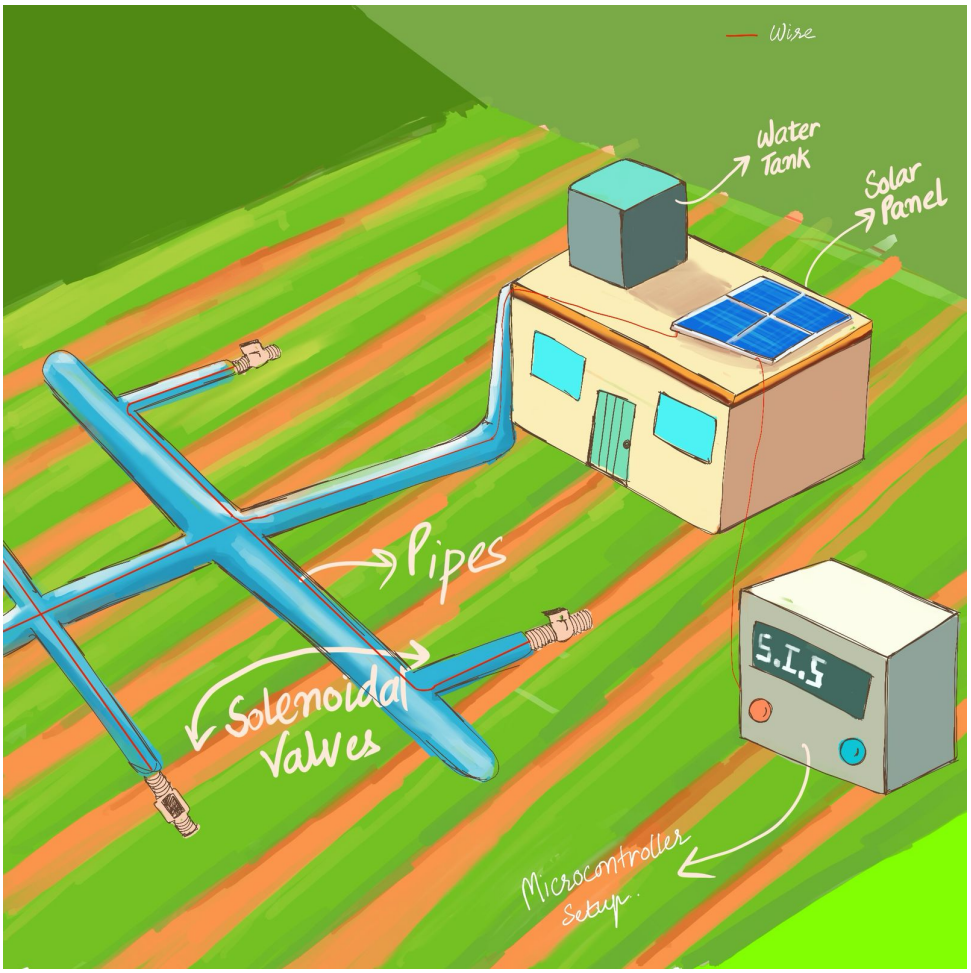
7 Conclusion and Future Scope

7.1 Conclusion

- Project SIS successfully demonstrates how automation and IoT can be integrated into agriculture to create a smart, efficient, and sustainable irrigation system. By using sensors to monitor soil moisture and water levels, along with Wi-Fi-based remote monitoring, the system ensures optimal water usage while reducing human effort. This project not only contributes to water conservation but also opens possibilities for further advancements in smart farming technologies.

7.2 Future Scope

- Rain Sensor: Prevents watering if it's about to rain.
- Solar Power: Makes the system eco-friendly and capable of operating off-grid.
- Mobile App: Enables remote control and sends alerts for better system management.
- Auto Fertilization: Automatically adds nutrients based on real-time soil requirements.



8 References

- https://docs.arduino.cc/tutorials/uno-rev3/intro-to-board/
- https://www.displaysino.com/technologyDetails/LCD-structure-and-principle.html
- https://www.elprocus.com/5v-relay-module/
- https://www.elprocus.com/esp8266-wi-fi-module/
- https://robu.in/product/soil-moisture-meter-soil-humidity-sensor-water-sensor-soil-hygrometer-ardunio/
- https://www.geeksforgeeks.org/dc-motor/
- https://www.instructables.com/Automatic-Irrigation-System-for-Indoor-Gardening-U/
- YouTube Channel: *The Technocrats*

9 Annexure l

9.1 Arduino

9.1.1 What is Arduino

Arduino is a simple and open platform used to create electronic projects. It includes both hardware and software that are easy to use. It can build devices that sense things like light or moisture and then respond by turning something on or off, like a motor or a light.

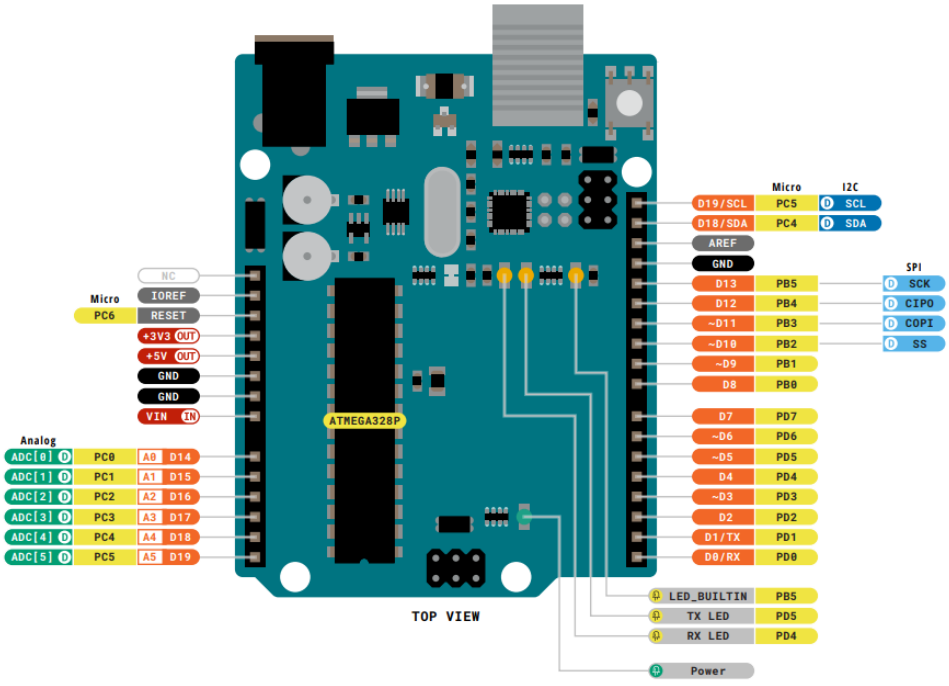
9.1.2 Types of Arduino

- Arduino Mega (R3)
- Arduino Uno (R3)
- Arduino Nano

9.1.3 Why Arduino Uno?

The Arduino Uno is often chosen for irrigation systems over other Arduino boards because it is simple to use, affordable, and provides enough processing power for the task. It is compatible with various sensors like soil moisture sensors, and it has plenty of memory and pins for connecting all the necessary components, such as pumps and relays.

9.1.4 Pinout Diagram of Arduino Uno



9.1.5 Specifications of Arduino Uno

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (Recommended): 7V – 12V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- Flash Memory: 32 KB
- USB Interface: Type-B USB for programming and communication

9.1.6 Advantages of Arduino Uno

- Easy to Use: Ideal for beginners with a simple and user-friendly programming environment.
- USB Programmable: Can be directly programmed via USB without additional hardware.
- Low Cost: Affordable and easily available.

9.1.7 Disadvantages of Arduino Uno

- Limited Processing Power: Not suitable for complex tasks requiring high performance
- No Built-in Connectivity: Lacks built-in Wi-Fi or Bluetooth; external modules are required

9.1.8 Application of Arduino Uno

- Home Automation Systems : Controls lights, fans, appliances, and security devices based on sensor inputs.
- Smart Irrigation Systems : Monitors soil moisture and automates watering schedules to save water.
- Robotics : Used in simple to complex robots, including line-following robots, obstacle-avoiding bots, and robotic arms.

9.2 Relay Module

9.2.1 Relay

A Relay is an electrical switch that can be used to control devices and systems that use higher voltages. In a relay, the mechanism is typically electromagnetic.

9.2.2 What is a Relay Module

Relay modules are simple circuit boards that include one or more relays, allowing for convenient control through microcontrollers like Arduino or ESP8266.

9.2.3 Principle of Relay Module

It operates on the principle of electromagnetic induction. This principle makes the relay fast and reliable for switching operations.

9.2.4 Why Relay Module?

- The primary use of a relay module is to electrically isolate the control circuit from the load circuit. This shields delicate components in the control system from damage due to high power.
- It can be used to amplify a signal — in other words, a small input current can control a much larger output current.

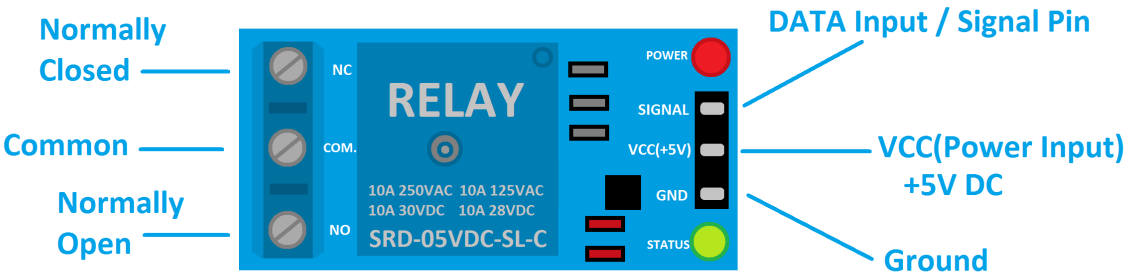
9.2.5 Specifications of Relay Module used

- Operating Voltage: 5V DC
- Trigger Voltage: 3.3V–5V (compatible with Arduino and ESP8266)
- Maximum Switching Voltage: 250V AC or 30V DC
- Maximum Switching Current: 10A
- Number of Channels: 1 (for a single relay module)
- Output Type: Normally Open (NO) and Normally Closed (NC) terminals
- LED Indicator: Built-in LED to show the relay status
- Optocoupler Isolation: Provides electrical isolation between control and load

9.2.6 5V Relay Module Configuration

The 5V relay module's pin layout is displayed below. This module has six pins; the purpose of each pin is explained below.

- Common Contact: This pin is used to connect through the load that we desire to switch by using the module.



5V Relay Module Pin Configuration

- Normally Closed (NC): This NC pin is connected through the COM pin to form a closed circuit. However, this NC connection will break once the relay is switched through providing an active high/low signal toward the signal pin from a microcontroller.
- Signal Pin: The signal pin is mainly used for controlling the relay. This pin works in two cases like active low otherwise active high. So, in active low case, the relay activates once we provide an active low signal toward the signal pin, whereas, in an active high case, the relay will trigger once we provide a high signal toward the signal pin.
- 5V VCC: This pin needs 5V DC to work. So 5V DC power supply is provided to this pin.
- Ground: This pin connects the GND terminal of the power supply.

9.2.7 5Volts 1-Channel Relay Module Components

A 5v relay module with a single channel is made up of the following parts: an input connection, a switching transistor, a status LED, a power LED, an output terminal, and a freewheeling diode.

- Relay : A 5V relay is coated with blue color plastic material. For both AC & DC loads, the utmost operating voltage & current are also displayed on the relay. This relay operates with 5V, so it is called a 5V relay.

- Output Terminal : The output terminal of the relay module is located at the left-hand side, used to fix an AC/DC load & AC/DC i/p power source. Every o/p connector's terminal is connected through NC, COM pins & NO of the relay.

- Status LED : Status LED is connected by using a current limiting resistor that is located on the top right side of the relay module. So this LED illustrates the relay status by activating the relay & coil through a signal pin. The DC supplies throughout a relay coil.

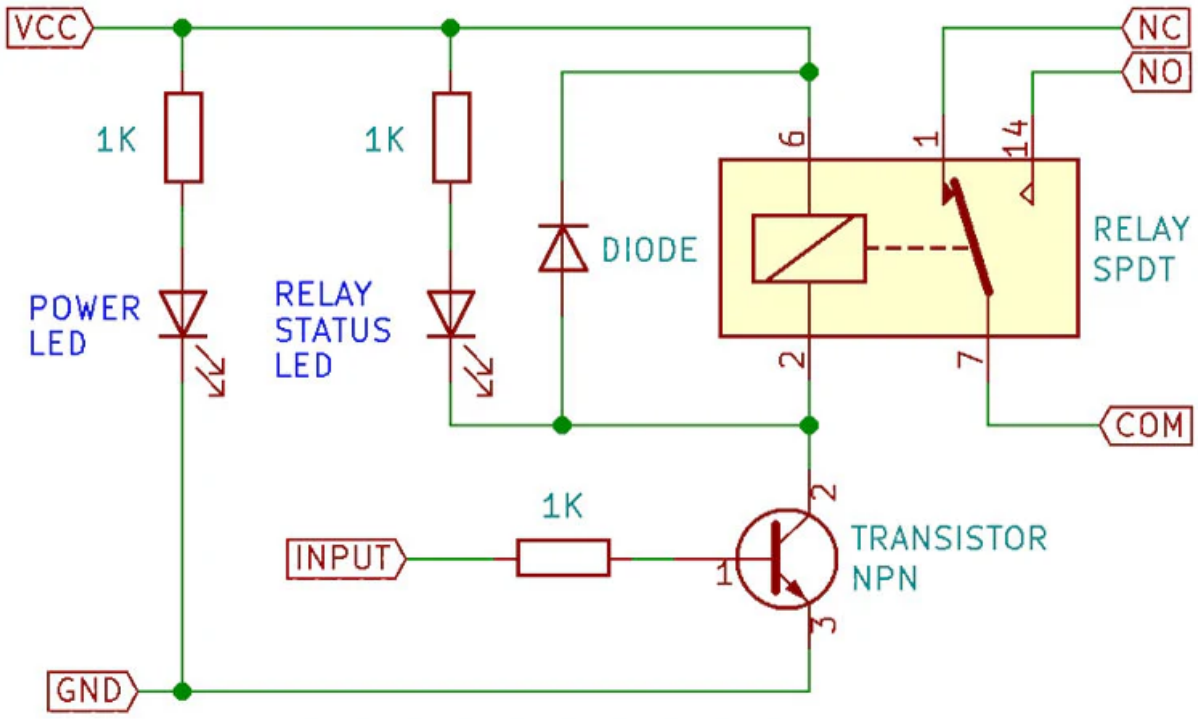
- Power LED : Power LED shows the condition of the power source that is connected through the single channel module. If we provide the above 5V source toward both the pins of the module like Vcc & GND, the LED will be damaged due to high voltage.

- Freewheeling Diode : done across the coil to keep away from the back EMF effect, so-called a flyback diode. The type of coil used in the relay is the inductive type. Once the current supplies throughout an inductive load, then it generates a back EMF voltage, which may harm the circuit. So, this diode is mainly used to keep away from this effect.

- Input Connector : The input connector is located on the right side of the module. This connector is mainly used to supply a 5V power supply & input signal. In addition, it also supplies power supply toward the power LED, relay coil & status LED.

- Swicthing Transistor : A switching transistor is used in this module is to strengthen the current to the requirement of the minimum current level of the relay coil. A switching transistor is used to control the 5V relay from the microcontroller's GPIO pin.

9.2.8 Relay Module Circuit Diagram



Relay Module Basic Schematic

9.2.9 Working of Relay Module

One relay module comes with an NPN transistor whereas another module comes with a PNP transistor. If the relay module uses an NPN Transistor, then it will activate the relay by applying an active high signal to the control pin. Alternatively, if a PNP is used then the relay will be activated through an active low signal on the control pin(As shown in above figure).

Switch Configurations:-

Relay modules are available with either normally open (NO) or normally closed (NC) switch configurations.

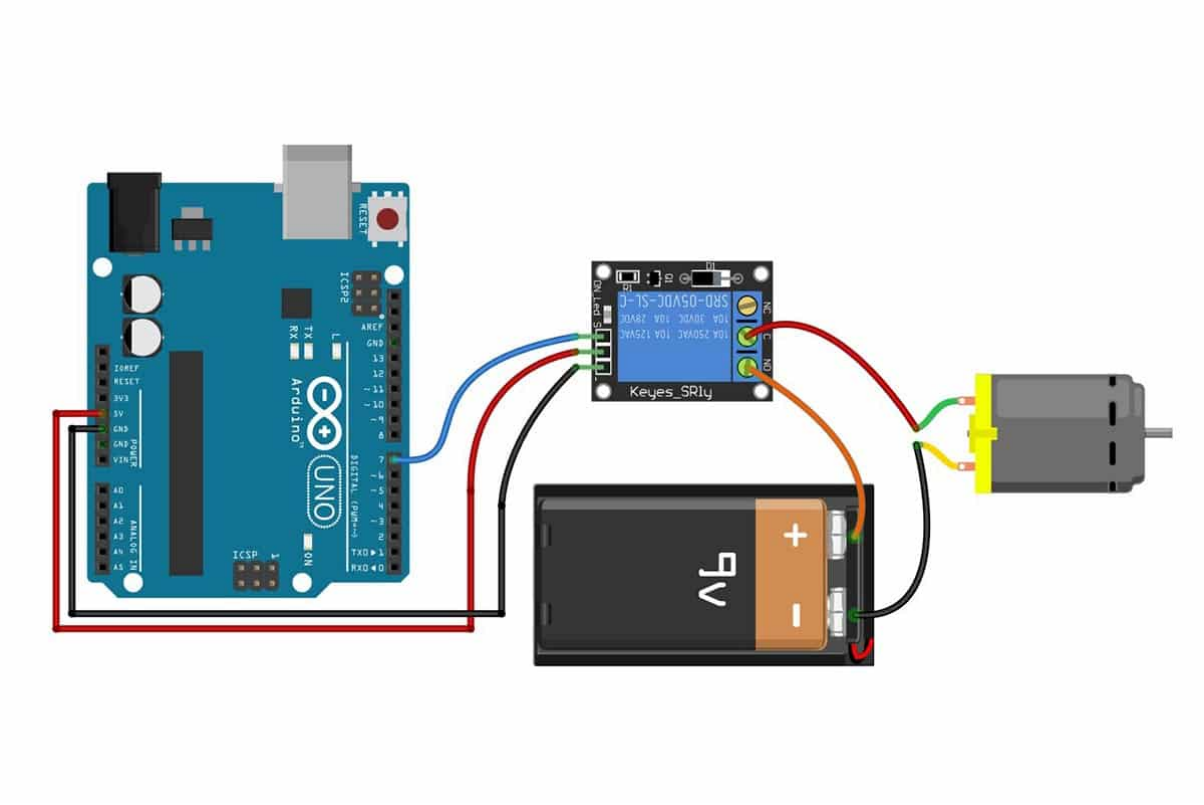
- A NO switch is open when the electromagnet is not activated, and closed when it is activated.
- An NC relay switch, on the other hand, remains closed by default and only opens when the relay is activated

Working:-

- The typical relay module connection points include an input side that consists of 3 or 4 jumper pins, and an output side that has 3 screw terminals.
- When the control signal is applied to the input side of the relay, it activates the electromagnet, which attracts an armature.

- This in turn closes the switch contacts on the output (high voltage) side, allowing electricity to flow and power the device or system that is connected to it.
- To prevent flyback voltage from damaging the relay module circuit and the input device, a diode is often placed in parallel with the electromagnet coil. This diode is known as a flyback diode. It allows current to flow in only one direction
- When a higher level of isolation is required, an optocoupler is used. An opto-isolated relay module has a photoelectric device on the input side, which is used to control the electromagnet's switching action.

9.2.10 Relay interfacing with Arduino



- VCC → Arduino 5V
- GND → Arduino GND
- IN → Arduino D7 (digital pin to control relay)

9.2.11 Relay interfacing with Pump

- COM (Common) → One wire from the external power supply
- NO (Normally Open) → Positive terminal of the pump
- Negative of the power supply → Negative of the pump

When the relay is activated, it closes the circuit and powers the pump.

9.2.12 Advantages of Relay

- A remote device can be controlled easily
- It is triggered with less current but it can also trigger high power machines
- Easily contacts can be changed
- It can switch AC or DC

9.2.13 Disadvantages of Relay

- When contacts of relay modules are used overtime then they may damage
- Noise can be generated through the opening & closing of the contacts.
- Time taken for switching is High

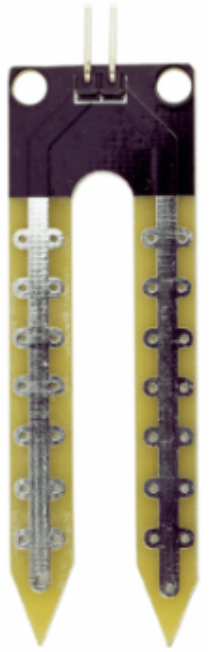
9.2.14 Application of Relay

- Home automation projects
- Control of alarm or security systems.
- Speed control of motors

9.3 Soil Moisture Sensor

9.3.1 What is Soil Moisture sensor?

A moisture sensor detects the water level in soil by measuring its electrical properties. It's used in irrigation systems to automate watering based on soil dryness.



Soil Moisture Sensor

9.3.2 Principle of Soil Moisture Sensor

A moisture sensor works on the principle that wet soil conducts electricity better than dry soil. It measures resistance or capacitance to determine soil moisture levels.

9.3.3 Types of Soil Moisture Sensor

- Resistive Sensor – Measures soil moisture by detecting changes in electrical resistance between two probes.
- Capacitive Sensor – Uses changes in capacitance caused by soil moisture without direct metal contact, making it more durable.

9.3.4 Why resistive over capacitive moisture sensor?

- Low Cost
- Easy to connect and program with Arduino
- Readily Available

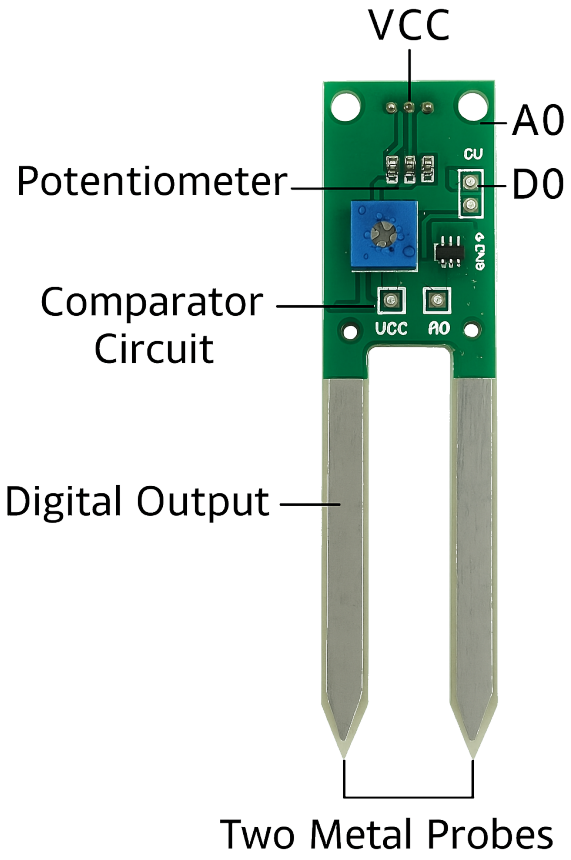


Figure 1: Enter Caption

9.3.5 Components Soil of Moisture Sensor

- Two Metal Probes – Act as electrodes to detect resistance in the soil.
- Comparator Circuit (Optional) – Converts analog signal to digital (HIGH/LOW) based on threshold.
- Potentiometer – Adjusts the sensitivity of the digital output.
- Output Pins (A0/D0) – Analog and digital signal outputs to connect with microcontrollers.
- VCC and GND Pins – For power supply (typically 3.3V–5V).

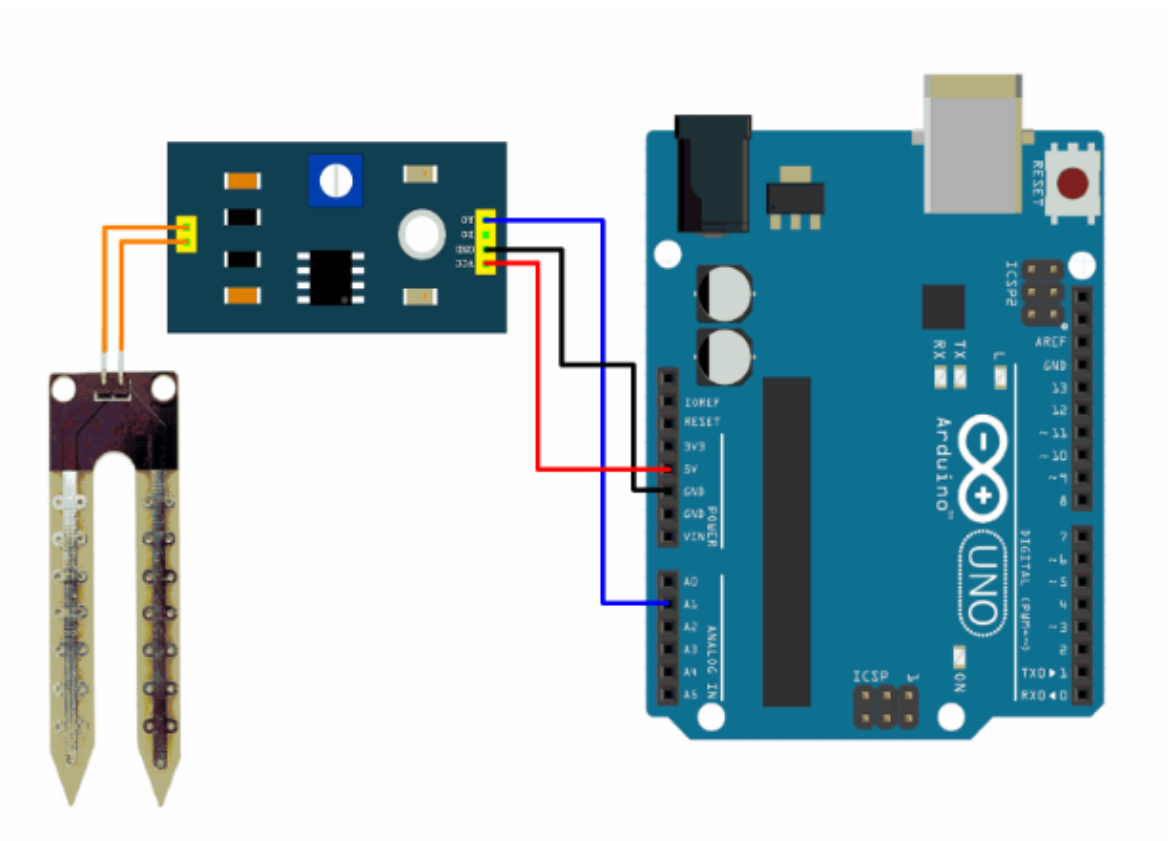
9.3.6 Working of Soil Moisture Sensor

The soil moisture sensor consists of two probes which are used to measure the volumetric content of water.

- The two probes allow the current to pass through the soil and then it gets the resistance value to measure the moisture value.
- When there is more water, the soil will conduct more electricity which means that there will be less resistance.Therefore, the moisture level will be higher.

- Dry soil conducts electricity poorly, so when there will be less water, then the soil will conduct less electricity which means that there will be more resistance. Therefore, the moisture level will be lower.

9.3.7 Interfacing of Soil Moisture Sensor with Arduino



Interfacing Soil Moisture Sensor With Arduino UNO

- VCC → Arduino 5V
- GND → Arduino GND
- A0 → Arduino A0

9.3.8 Features of Soil Moisture Sensor

- Dual output mode, analog output more accurate
- A fixed bolt hole for easy installation
- With power indicator (red) and digital switching output indicator (green)

9.3.9 Advantages of Soil Moisture Sensor

- Water-saving – Prevents over-watering by monitoring real-time soil moisture.

- Automation-friendly – Can be integrated with irrigation systems and Arduino for smart farming
- Simple and Affordable – Easy to use and cost-effective, especially resistive types
- Real-time Monitoring – Provides instant feedback on soil condition

9.3.10 Disadvantages of Soil Moisture Sensor

- Accuracy Issues – Affected by soil type, temperature, and sensor quality
- Needs Calibration – Must be calibrated for different soils and moisture levels
- Power Sensitivity – Continuous power supply can reduce durability

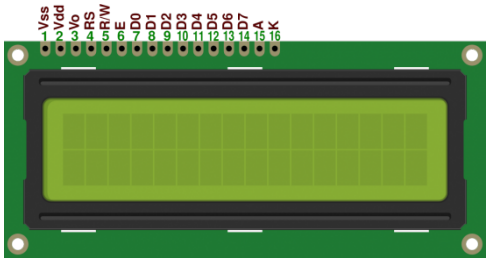
9.4 16x2 LCD display

9.4.1 What is LCD?

The term LCD stands for liquid crystal display.It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc.

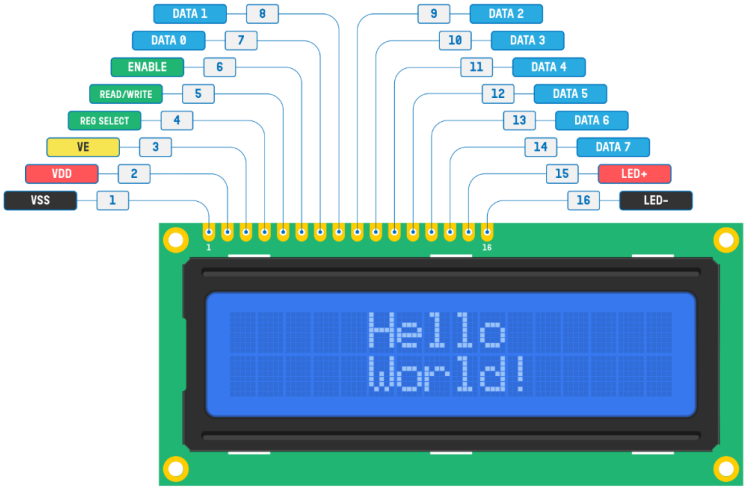
9.4.2 What is meant by 16x2 in a 16x2 LCD display?

- "16" means it can show 16 characters in a single row.
- "2" means it has 2 rows (or lines) total.
  So, a 16x2 LCD can show a total of 32 characters at once (16 characters × 2 lines).



Liquid Crystal Display

9.4.3 LCD 16×2 Pin Diagram

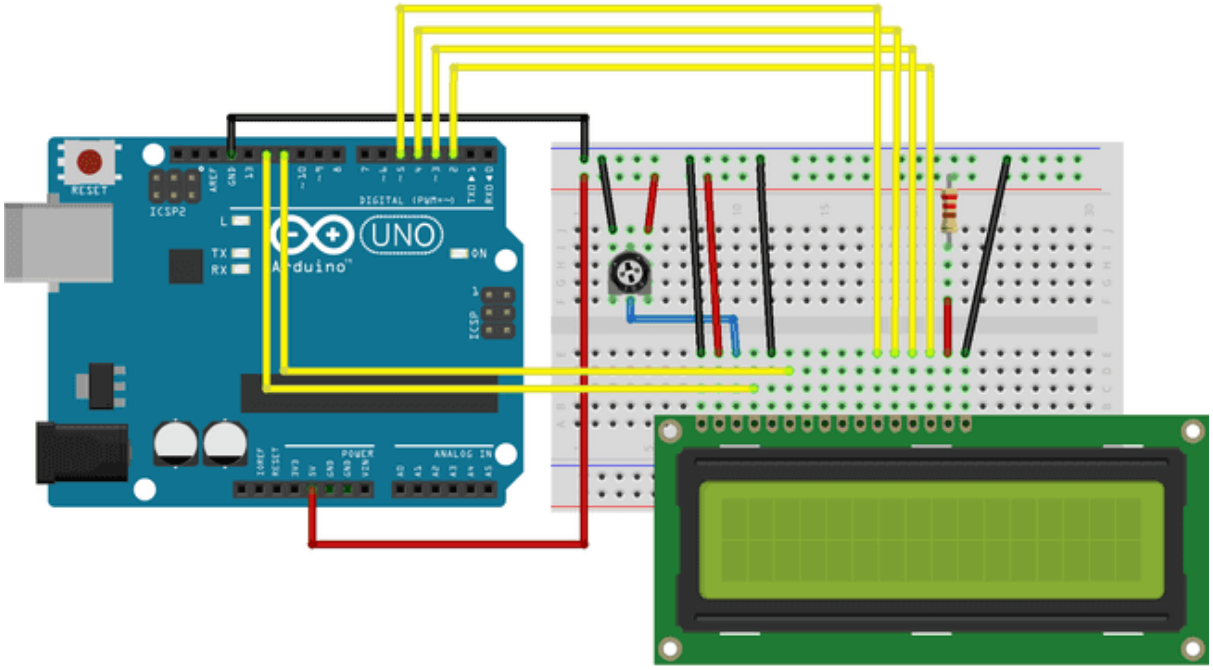


9.4.4 Description of pins of LCD 16x2

- Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.
- Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.
- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
- Pin15 (+ve pin of the LED): This pin is connected to +5V
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

9.4.5 LCD Interfacing with the Arduino Module

Here below the schematic diagram of LCD with arduino module



- RS pin of the LCD is connected to the pin 12 of the Arduino.
- The LCD of R/W pin is connected to the ground
- The pin 11 of the Arduino is connected to the enable signal pin of LCD module.
- The digital input lines (DB4-DB7) are interfaced with the Arduino pins from 5-2.

  To adjust the contrast of the display here we are using a 10K potentiometer. The current through the back LED light is from the 560-ohm resistor.

9.4.6 Features of LCD

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit

9.4.7 Advantages of LCD

- Low cost
- Less power consumption

9.4.8 Disadvantage of LCD

- Occupies large area
- slow devices
- Lifespan of the devices will be reduced due to direct current

9.4.9 Application of LCD

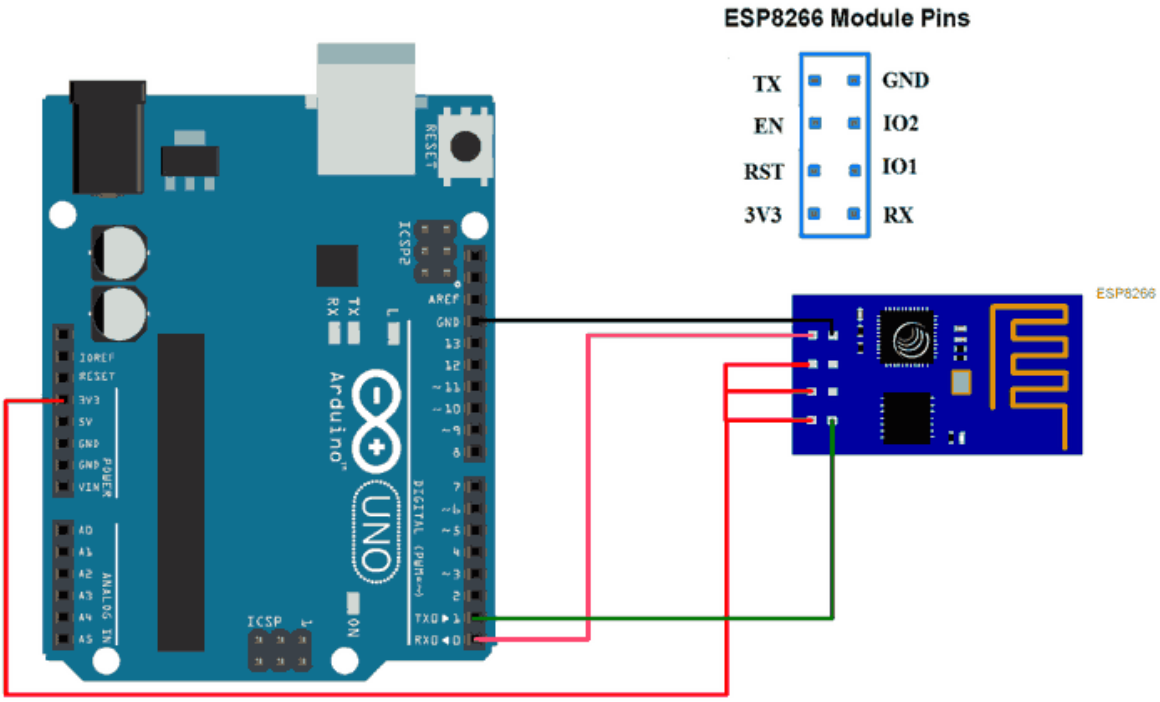
- Embedded Systems :- Used in microcontroller-based projects to display sensor data, system status, or messages
- Smart Irrigation Systems :- Displays soil moisture levels, pump status, and connectivity messages in real-time
- Home Automation :- Shows temperature, light intensity, and control feedback in smart home devices
- Electronic Voting Machines :- Displays voting options and confirmation messages for user interaction

9.5 Esp8266

9.5.1 What is the ESP8266?

The ESP8266 is a low-cost Wi-Fi module used to connect devices to the internet. It is widely used in IoT(Internet of Things) projects for wireless communication and remote control.

9.5.2 Interfacing of ESP8266 with Arduino



- ESP8266 VCC → 5V (from Arduino)
- ESP8266 GND → GND (from Arduino)
- ESP8266 RX (Receive) → Arduino TX (Pin 1)
- ESP8266 TX (Transmit) → Arduino RX (Pin 0) (Use a voltage divider to reduce 5V to 3.3V if needed)

9.5.3 Features of ESP8266

- Networking: The module's Wi-Fi antenna enables embedded devices to connect to routers and transmit data
- Data Processing: Includes processing basic inputs from analog and digital sensors for far more complex calculations
- P2P Connectivity: Create direct communication between ESPs and other devices using IoT P2P connectivity

9.5.4 Advantages of ESP8266

- Wi-Fi Connectivity: Provides easy integration with Wi-Fi networks for internet-based communication
- Low Power Consumption: Suitable for battery-powered applications due to its power efficiency
- Small Size: Compact design allows it to fit in small devices
- Ease of Use: Can be programmed using the Arduino IDE, making it beginner-friendly.

9.5.5 Disadvantage of ESP8266

- Limited Processing Power: It has limited processing capabilities compared to more powerful microcontrollers, which may not be suitable for complex tasks
- Limited GPIO Pins: The number of GPIO pins is relatively small, which can limit the number of sensors or devices that can be connected
- No Built-in Bluetooth: Unlike some other modules, it lacks Bluetooth functionality for local communication

9.5.6 Applications of ESP8266

- Smart Irrigation Systems :- Sends soil moisture data to the cloud and enables remote control of water pumps
- Home Automation :- Controls lights, fans, and appliances via smartphone or voice assistants using Wi-Fi
- Weather Stations :- Sends temperature, humidity, and pressure data online for remote weather tracking