MINI PROJECT REPORT

on

AUTOMATIC IRRIGATION SYSTEM

Submitted by

ROOPESH O R (20323085)
ROSHNA PALATTY SANTHOSH (20323086)
SUMAYYA PUNNOTH (20323100)
MERELLA JOBI (20323113)

in partial fulfillment of requirement for the award of the degree of

BACHELOR OF TECHNOLOGY
in
ELECTRONICS AND COMMUNICATION

DIVISION OF ELECTRONICS ENGINEERING
SCHOOL OF ENGINEERING
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI - 682022

APRIL 2025

DIVISION OF ELECTRONICS ENGINEERING
SCHOOL OF ENGINEERING
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI-682022

CERTIFICATE

Certified that the mini project report entitled ***"AUTOMATIC IRRIGATION SYSTEM"*** *is a bonafide work of* ***ROOPESH O R, ROSHNA PALATTY SANTHOSH, SUMAYYA PUNNOTH, MERELLA JOBI*** *towards the partial fulfillment for the award of the degree of B.Tech in Electronics and Communication of Cochin University of Science and Technology, Kochi-682022.*

Mini Project Guide **Head of the Division**

Acknowledgment

The satisfaction that accompanies the successful completion of the project would be incomplete without the mention of the people who made it possible. We consider ourself privileged to express gratitude and respect towards all those who guided us through the completion of this project.

We express our indebtedness in God Almighty for the successful completion of our project. First and foremost, we express our sincerest regards to our project guides, Anju Maria, Premkumar C V and Sherin Abraham for their valuable inputs, guidance cooperation and constructive criticism throughout the duration of our project. We deeply express our sincere thanks to our Head of Department, Dr. Deepa Sankar for encouraging and allowing us to present the project at our department premises.

We take this opportunity to thank all our lecturers who directly or indirectly helped our project. We pay respect and love to our parents and all other family members and friends for their love and encouragement throughout our career. Last but not the least we express our thanks to our friends for their cooperation and support.

Abstract

With the increasing demand for food production and the growing unpredictability of natural rainfall patterns, efficient irrigation techniques have become more important than ever. Traditional irrigation methods such as flood irrigation, furrow irrigation, and basin irrigation are highly inefficient and often lead to water wastage, uneven water distribution, nutrient leaching and increased labour requirement. An automatic irrigation system overcomes these issues by addressing the critical need for efficient water management in agriculture. It aims to automate the plant watering process and minimise human intervention. The system is designed and implemented with wireless communication and remote monitoring to ensure optimal water utilization. The key components used in the project are RF Transmitter and Receiver modules, Encoder, Decoder, Relay and Motor. The system also makes use of a NodeMCU for remote monitoring. The transmitter section works by utilising a soil moisture sensor to continuously monitor the moisture level of soil, encoding and transmitting the data. The receiver section receives this data, decodes and activates the motor through a relay which pumps the water. Once sufficient moisture is detected, the water pump is turned off. This data can be accessed through a webpage hosted by NodeMCU. By using RF communication, wiring constraints are eliminated, making the system suitable for remote and wide-area applications. The project demonstrates how automation and wireless technology can be effectively combined to achieve efficient and sustainable irrigation.

Table of contents

List of Tables

List of Figures

Chapter 1
Introduction

In recent years, agriculture and gardening have increasingly adopted automation technologies to optimize resource usage and improve crop yield. One critical factor for successful plant growth is adequate and timely irrigation, yet many traditional irrigation practices are based on fixed schedules or manual observations, which can be inefficient. Water, being one of the most precious resources, is often overused in agricultural systems, especially in areas where it is already scarce. In this context, an automatic irrigation system offers a promising solution by supplying water only when and where it is needed, based on real-time environmental conditions.

The primary objective of this project is to develop a low-cost, automatic irrigation system that leverages soil moisture sensing and wireless RF communication to automate the operation of a water pump based on soil moisture conditions. The system is designed to operate autonomously, detecting when the soil becomes too dry and initiating irrigation, and then turning off the pump once optimal moisture levels have been restored. This approach not only ensures that plants receive water precisely when they need it, but also minimizes water consumption and labor. Furthermore, by using a simple yet effective 433 MHz RF communication setup, the system allows for wireless transmission of data between distant transmitter and receiver units, making it especially useful in outdoor environments or locations where wiring may be impractical.

The irrigation system comprises two main units: a transmitter and a receiver. At the transmitter end, a soil moisture sensor continuously monitors the moisture level in the soil. The sensor produces a digital signal depending on whether the moisture content is above or below a predefined threshold. This signal is fed into an HT12E encoder IC, which prepares the data for wireless transmission through a 433 MHz RF transmitter module. On the receiver side, the signal is received by an RF receiver module and decoded using an HT12D decoder IC. Based on the received data, a switching circuit drives a relay module to control a water pump. When the soil is dry, the relay is activated to turn the pump on; once the soil becomes sufficiently moist, the system sends an updated signal to the receiver, which in turn deactivates the relay, switching off the pump.

An additional feature of this system is the integration of a NodeMCU (ESP32) microcontroller, which acts as a web server to provide real-time monitoring through a webpage. The receiver unit sends updates to the NodeMCU, which then displays the pump activation (ON/OFF), connectivity and soil status on a simple web interface. This allows users to remotely track irrigation activity from any device connected to the same network, providing transparency and convenience.

Compared to traditional irrigation methods such as flood, furrow, and basin irrigation, which are known for their simplicity but suffer from significant inefficiencies, the automatic irrigation system offers a more sustainable and precise solution. Traditional methods often lead to water wastage through evaporation, deep percolation, and runoff, while also risking overwatering or underwatering of crops. Even sensor-assisted micro-irrigation systems, though more accurate, generally rely on manual intervention and scheduled watering. In contrast, the developed system fully automates the irrigation process by using real-time soil moisture data and wireless RF communication. Water is delivered only when necessary, minimizing wastage and preserving soil health. The inclusion of a NodeMCU for web-based monitoring further enhances the system by enabling remote access to soil conditions and system status.

This system is especially beneficial in large agricultural fields or greenhouses where continuous human monitoring is not feasible. It can help reduce the burden on farmers, optimize water usage, and improve the overall health of plants.

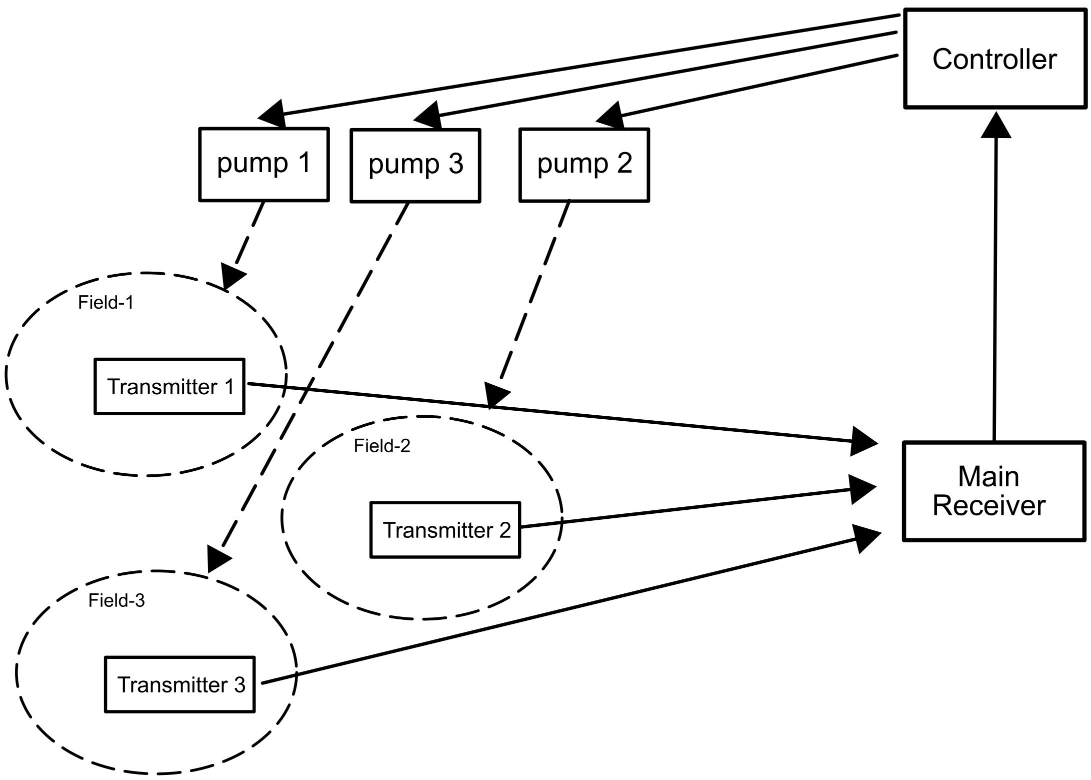

Fig. 1.1: A practical system to control irrigation in multiple fields

In addition, the use of RF-based communication makes the system scalable and adaptable, as multiple transmitter units can potentially be deployed in different zones of a field, all communicating wirelessly with a central control unit. A model of such system is given in Fig 1.1. The system can also be integrated with existing micro irrigation systems in the farmland to aid the automation of irrigation. The system is based on a simple model proposed in an issue of EFY Express magazine [4]

Chapter 2
Literature Review

Irrigation is a vital agricultural practice that enables controlled water delivery to crops, ensuring their optimal growth. Traditionally, surface irrigation methods such as flood irrigation, furrow irrigation, and basin irrigation were the most widely used due to their simplicity and low cost. However, these methods are highly inefficient, leading to significant water loss through evaporation, deep percolation, and runoff. They often result in overwatering or underwatering, soil erosion, affecting both crop yield and soil health. The addition of soil monitoring sensors can provide more accurate decisions on irrigation scheduling in a micro irrigated field. [1]

Micro-irrigation has emerged as a critical solution for improving water use efficiency in agriculture, especially under increasing water scarcity. One such method known as Drig irrigation is shown in Fig 2.1. The advantages over conventional methods include precise water delivery, reduced evaporation and minimal runoff. Recent advances such as real-time soil moisture sensors, automation, and nano-filtration have expanded its potential. The study emphasizes the need for innovation, policy support, and cost-effective solutions to broaden micro-irrigation's reach and impact. To overcome these limitations, researchers have explored technology-assisted irrigation systems, which use sensors and actuators to automate water delivery based on real-time soil and environmental parameters. These systems can ensure timely and precise irrigation, significantly reducing water wastage and improving crop health. Moreover, by utilizing microcontrollers and wireless communication modules, such systems can operate remotely and autonomously with minimal human intervention. [2]

Fig. 2.1: Drip irrigation

Recent literature emphasizes the growing need for automated irrigation systems equipped with real-time soil moisture sensors and remote control mechanisms. These systems reduce labor requirements, improve water-use efficiency, and enhance crop yield consistency. Wireless modules enable remote monitoring and control, making such setups highly suitable for large-scale or remote farms. This approach aligns well with sustainable agriculture goals and modern irrigation strategies, offering a practical solution to operational delays and water resource inefficiencies [3].

In the project, an automatic irrigation system is proposed using RF communication and a NodeMCU-based monitoring unit. The system tries addresses the shortcomings of traditional irrigation methods by delivering water based on real-time soil moisture conditions, thereby minimizing wastage and ensuring consistent irrigation.

Chapter 3
Automatic Irrigation System

Following pages outlines various levels of design aspects of the system including block diagram, circuit diagram, specification of major components, detailed documentation of certain aspects of circuit as well as a PCB design of the system.

3.1 Block diagram

The block diagram of the system is shown in Fig 3.1. The soil moisture sensor placed in the soil in the field produces a digital signal representing whether soil is dry or not. This is generated by comparing moisture level and a set reference voltage. This signal is encoded and transmitted over radio.

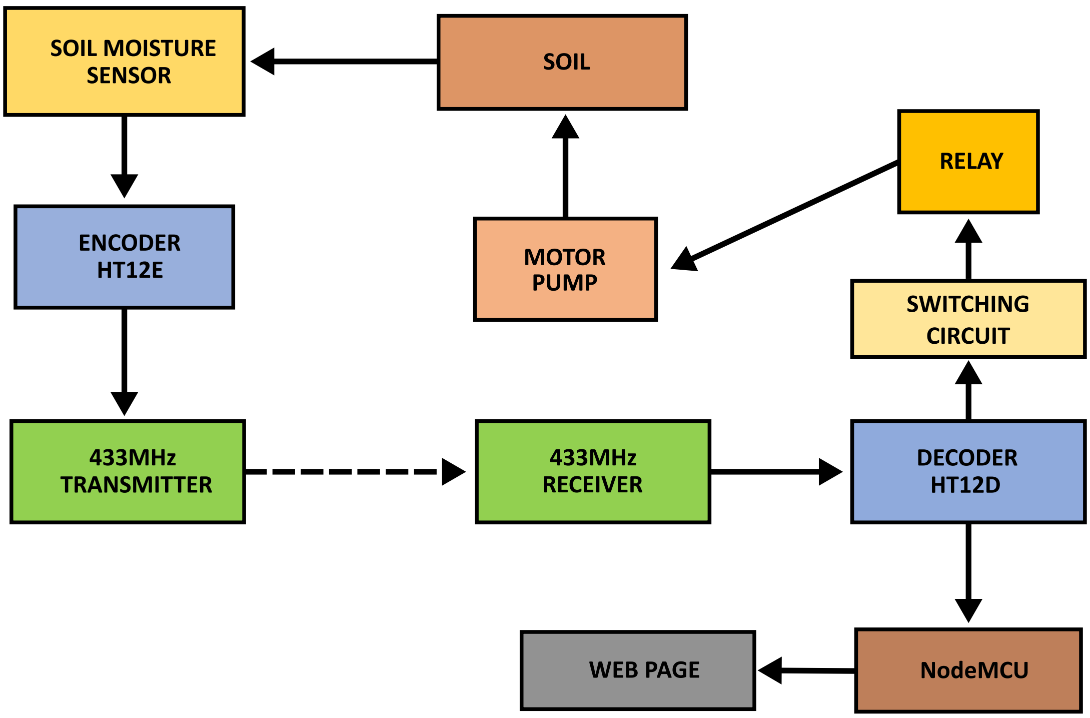

Fig. 3.1: Block Diagram of the system

This signal is received and decoded at a receiver setup in the home. Based on the signal received, the receiver drives a switch which actuates the relay and hence the water pump, supplying water to the field. The status of soil moisture and connectivity of the system is read by NodeMCU and updates the status on a website hosted in NodeMCU. The overall system works in a continuous feedback loop

3.2 Components

The following section describes the specification of various componets choosen for implementing the project. This includes sensors, radio modules, encoder/decoder ICs, Wi-fi module, etc.

3.2.1 Soil Moisture Sensor

The Resistive Soil Moisture Sensor Module consists of two probes which are used to measure the moisture content of soil. A photo of such sensor is given in Fig 3.2. Resistive soil moisture sensors work by measuring the resistance of the soil, which changes with moisture content, with higher moisture leading to lower resistance. The sensor uses two probes to pass a current through the soil, and the resistance encountered is used to estimate moisture levels. The sensing circuit is calibrated to different soil types for proper measurement by adjusting the built in potentiometer

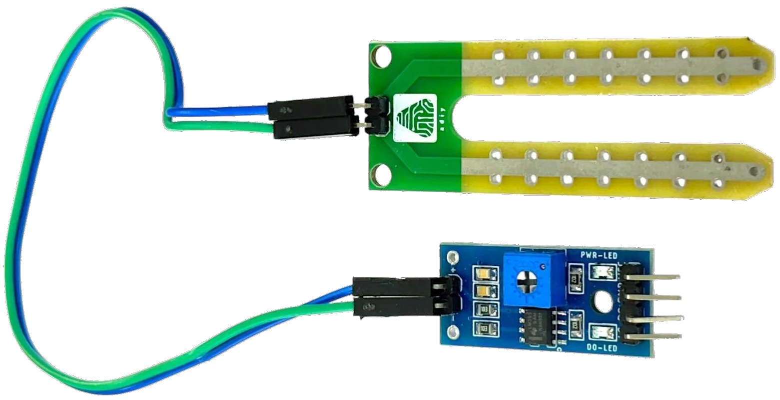

Fig. 3.2: Soil moisture sensor

3.2.2 FS1000A: Transmitter & Receiver module

FS1000A is a combination of two modules used for data transmission and reception. The core of the transmitter module is a SAW resonator tuned to operate at 433MHz. Apart from that, it has a switching transistor and some passive components. When the DATA input is high, the oscillator generates a constant RF output carrier wave at 433MHz, and when the DATA input is low, the oscillator ceases operation; resulting in an amplitude modulated wave. The module can cover a minimum of 10 meters and with proper antenna and power supplies. Theoretically it can transmit up to 100 meters [5]. Fig 3.3 shows a photo of the device.

The Receiver module consists of an RF tuned circuit and an Op-Amp that amplify the received carrier wave. The amplified signal is then fed into a PLL Phase Lock Loop, which allows the demodulator to "lock" onto frequency of incoming signal. The demodulated signal is preset at two output pins which are internally connected

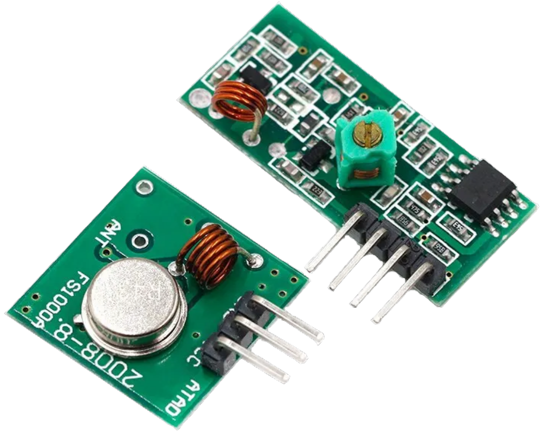

Fig. 3.3: FS1000A receiver and transmitter pair

3.2.3 HT12E: Encoder IC

The function of HT12E is to encode a 4-bit data and 8-bit address and send it out through the output pin. The IC has operating voltage ranging from 2.4V to 5V with typical value of 3V. The Transmission Enable pin (pin 14) is pulled to ground to activate transmission. The 4-bit data that has to be sent is given to the pins AD8 to AD11 and an address of 8-bit is set using the pins A0 to A7. Moreover a resistor has to be connected between OSC1 and OSC2 pins to set the operation frequency of encoder. The value of this resistor is chosen according to the oscillator frequency characteristics provided in the datasheet [6]. The pinout of the IC is shown in Fig 3.4

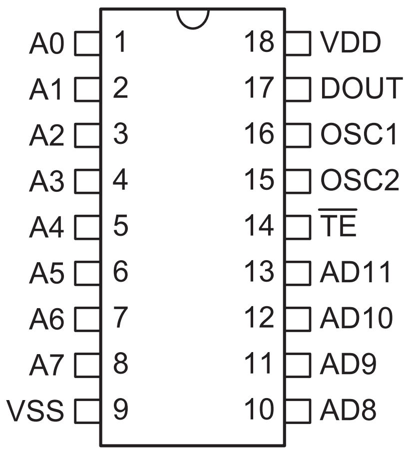

Fig. 3.4: HT12E encoder IC pinout

3.2.4 HT12D: Decoder IC

The function of HT12D is to decode the data obtained from a receiver circuit and send it through the output pins. The IC has a wide range of operating voltage from 2.4V to 12V with typical voltage being 5V. A signal on the DIN pin activates the oscillator which starts decoding of the incoming signal and obtains data and address in it. The decoder will then check if the received address matches with the preset address three times continuously. If it matches, the 4-bits of data are decoded to activate the output pins D8-D11 and the VT pin is set high to indicate a valid transmission [7]. The pinout of the IC is shown in Fig 3.5

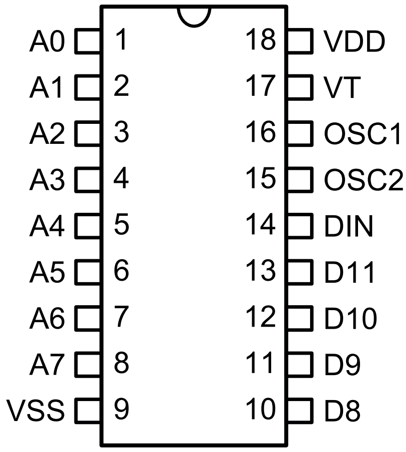

Fig. 3.5: HT12D decoder IC pinout

3.2.5 BC547B: Transistor

The BC547B, an NPN transistor, can handle current up to 200mA. The gain current of this transistor is from 110 to 800. The maximum base to emitter reverse voltage it can handle is 6V and maximum collector to emitter voltage is 45V. The transistor is available in the TO-92 package [8]. Fig 3.6 shows a photo of the transistor in TO-92 package. The transistor is employed in the circuit to drive the relay.

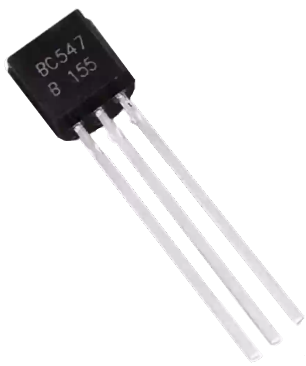

Fig. 3.6: BC547 transistor

3.2.6 JQC-3FC(T73)DC05V: Relay

This is an electromechanical relay that mechanically switches contact between two points. The relay is operated by applying a voltage across the coil pins. When coil gets energized producing a magnetic field that actuates a contact lever. When the coil is de-energized the contact returns to normal position. The relay we used can handle switching of 120V 10A AC supply or 24V 10A DC supply. The relay can switch at most 60Hz. The coil has to be powered by a 5V supply in order for it to actuate the contact [9]. The relay is driven by a transistor switch as the ICs used cannot handle the current required to drive the relay. Fig 3.7 shows the relay used in this project.

Fig. 3.7: PCB Mount Relay

3.2.7 18650 Battery and case

An 18650 battery is a cylindrical, lithium-ion rechargeable battery, named for its dimensions (18mm diameter and 65mm length), known for its high energy density and long lifespan. Here we have used a 3.7V 18650 battery with 2600mAh capacity. Fig 3.8 shows battery and its case. This battery was chosen for the transmitter circuit as it can power the circuit for months without recharge in (ideal conditions)

Fig. 3.8: 18650 battery and its holder

3.2.8 DC Motor Pump

A 6V DC motor pump is utlilized to supply water to the field. The motor consumes 4-5W of power. The motor can work from 3V to 9V. It can supply water up to a height of 110cm at maximum operating voltage. [10] For the purpose of demonstration, the motor is powered by a regulated power supply that can supply 5V DC. Fig 3.9 shows a view of the motor.

Fig. 3.9: DC motor pump

3.2.9 NodeMCU Development Board

The NodeMCU ESP32 is a development board based on the ESP32 microcontroller. It is programmable with various programming languages. This board has 2.4 GHz dual-mode Wi-Fi and a BT wireless connection. In addition, a 512 KB SRAM and a 4MB flash memory are integrated into the microcontroller development board. The board has 21 pins for interface connection, including I2C, SPI, UART, DAC, and ADC. The NodeMCU's ADC (Analog-to-Digital Converter) input is configured for the 0-3.3V range with absolute maximum rating of 3.6V [11]. The module can be powered using an external supply through its micro USB port or with 5V and GND pins in the board. A view of NodeMCU used in the project is shown in Fig 3.10

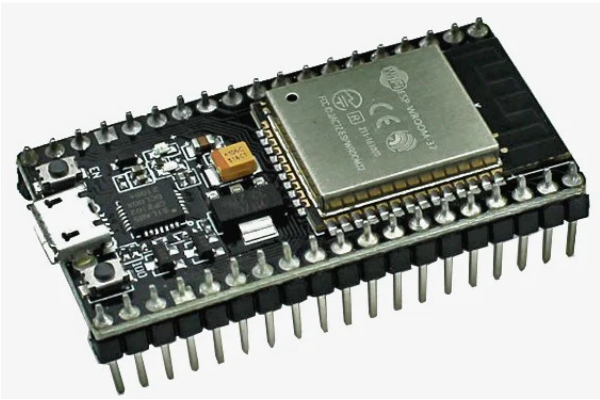

Fig. 3.10: NodeMCU ESP32

3.3 Circuit Diagrams

In this section, circuit diagrams of both transmitter and receiver circuits are shown along with a detailed explanation of their operation. The circuits were designed using KiCad software.

3.3.1 Transmitter

Fig 3.11 shows the circuit diagram of the transmitter circuit. The resistive soil moisture sensor placed in the soil continuously senses the water level of the soil, providing a digital output from the DO pin of the sensor based on a set threshold level. The sensor gives a high output if the water content falls below the threshold level, and a low output otherwise. This digital signal is directly fed into the input data pin AD8 (pin 10) of the HT12E encoder. The address pins A0 to A7 (pins 1 to 8) of the encoder are set to 0. The HT12E encoder then takes this digital signal and encodes it with the address creating a data packet. The data packet obtained from DOUT (pin 17) is then sent to an RF transmitter module's data input pin DATA for modulation and wireless transmission. This RF transmitter modulates the digital data onto a radio frequency carrier signal of 433MHz and then transmits it wirelessly via an antenna of length 20cm. This transmission occurs continuously based on the data from the moisture sensor.

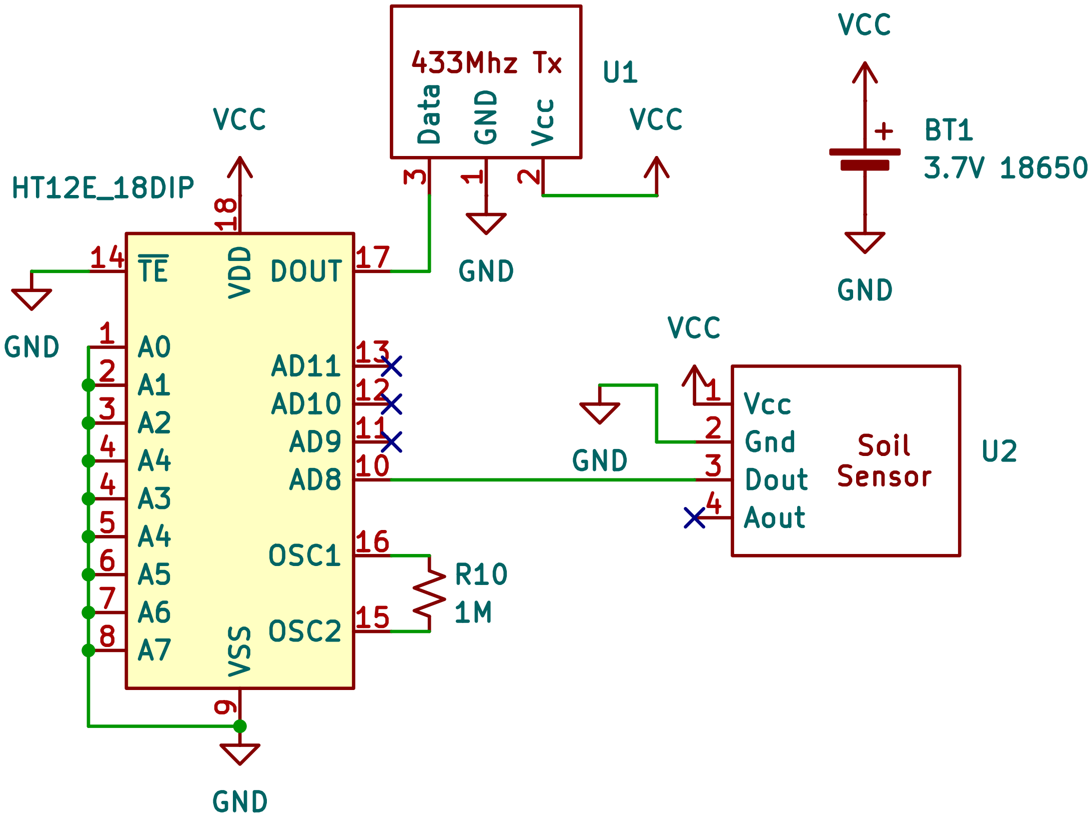

Fig. 3.11: Transmitter circuit

3.3.2 Receiver

Fig 3.12 shows the circuit diagram of the transmitter circuit. The RF receiver module tuned at 433MHz receives the radio frequency signal transmitted by the transmitter unit. The RF module demodulates the received signal. This decoded data is then fed into the HT12D decoder's data input pin DIN (pin 14). The decoder is configured with the same address as the HT12E encoder in the transmitter by setting the address pins A0 to A7 (pins 1 to 8) to ground. It checks the address portion of the received data to ensure it matches its own. If the addresses match, the decoder extracts the data portion of the signal and presents it through its output data pins D8-D11. This extracted digital data represents the soil moisture status and is then taken from D8 (pin 10). The data is then given to a relay such that it only turns on if data is high (i.e., water content is low) and transmission is valid. This is achieved by using two transistors in an AND gate configuration that takes the values from VT (pin 17) and D8 (pin 10) as input.

The relay module is wired in a normally OFF configuration. It is switched to ON state when both VT and D8 pins are high. This turns on a water pump that is connected to the relay and pumps water to the plants. When the received digital data from the soil moisture sensor becomes low and the switching circuit turns off relay and it switches back to OFF state which turns the water pump off.

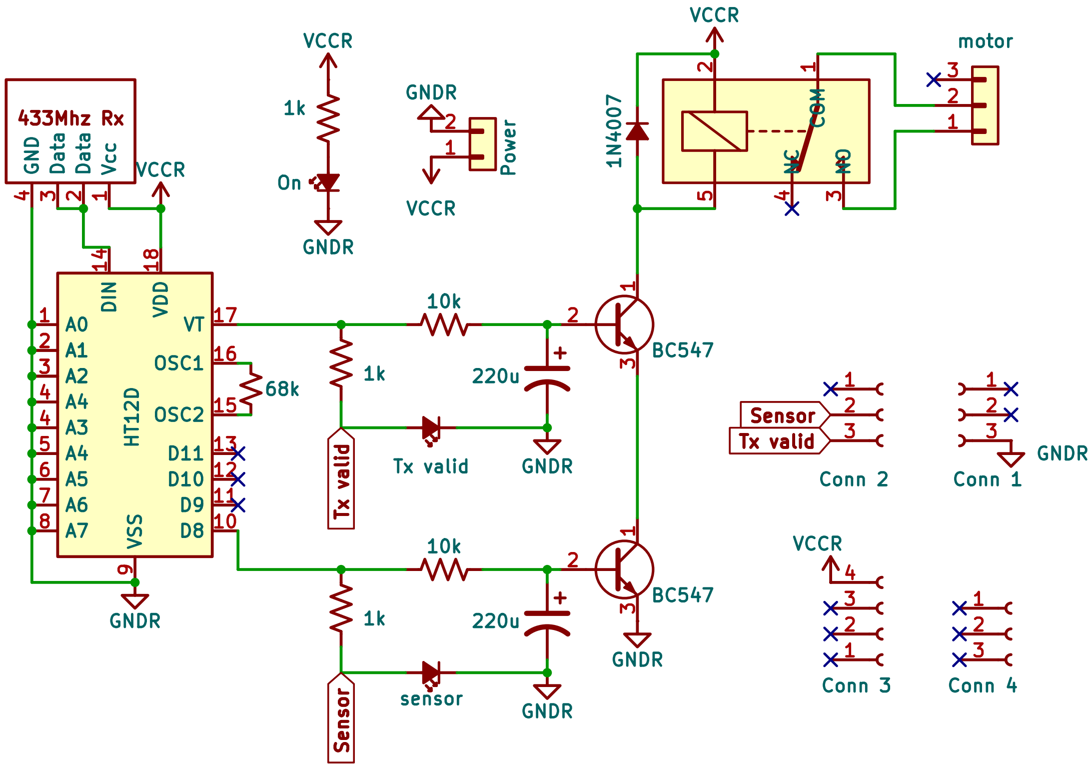

Fig. 3.12: Receiver circuit

3.4 Tuning circuit parameters

For the proper working of the circuit some values of components has to be calculated using data given in the datasheet. This section describes those aspects of the design.

3.4.1 Encoder IC oscillator

The encoder is powered by a voltage supply of 3.7V. An arbitrary value of 1MΩ as recommended by the manufacturer is chosen for the resistor across the oscillator pins OSC1 and OSC2 (pins 16 and 15). From the Oscillator Frequency vs Supply Voltage graph of the encoder IC shown in Fig 3.13, the oscillation frequency corresponding to the oscillator resistor value of 1MΩ and supply voltage of 3.7V is found to be 2.71kHz. This value is crucial for calculating the oscillator resistor for the decoder IC

3.4.2 Decoder IC oscillator

The recommended oscillator frequency for the decoder is 50 times that of the encoder's frequency. In this case, for and encoder frequency of 2.71kHz, the decoder frequency has to be 135kHz. The decoder is powered by a voltage supply of 5V. From the Oscillator Frequency vs Supply Voltage graph of the decoder shown in Fig 3.14, it can be seen that the resistor value corresponding to a 5V supply voltage and calculated oscillation frequency (135kHz) is 62kΩ. However 68kΩ was the resistor value available while the construction of prototype which is nearest the calculated value. Upon testing, this slight change in resistance did not produce much deterioration in the communication system. This resistor is connected across the pins OSC1 and OSC2

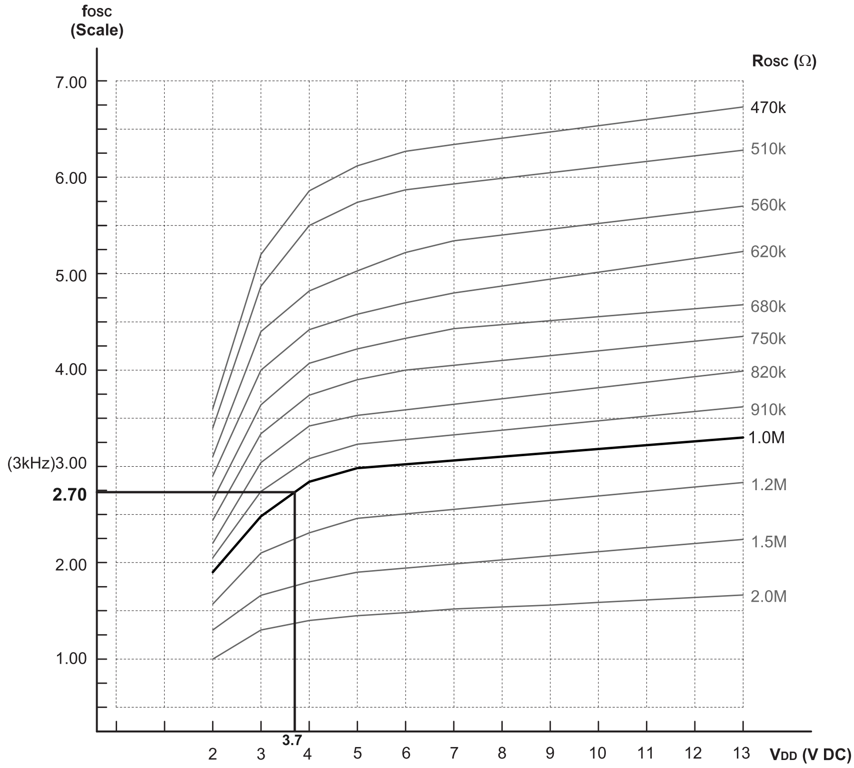

Fig. 3.13: Plot of Oscillator frequency vs supply voltage for HT12E

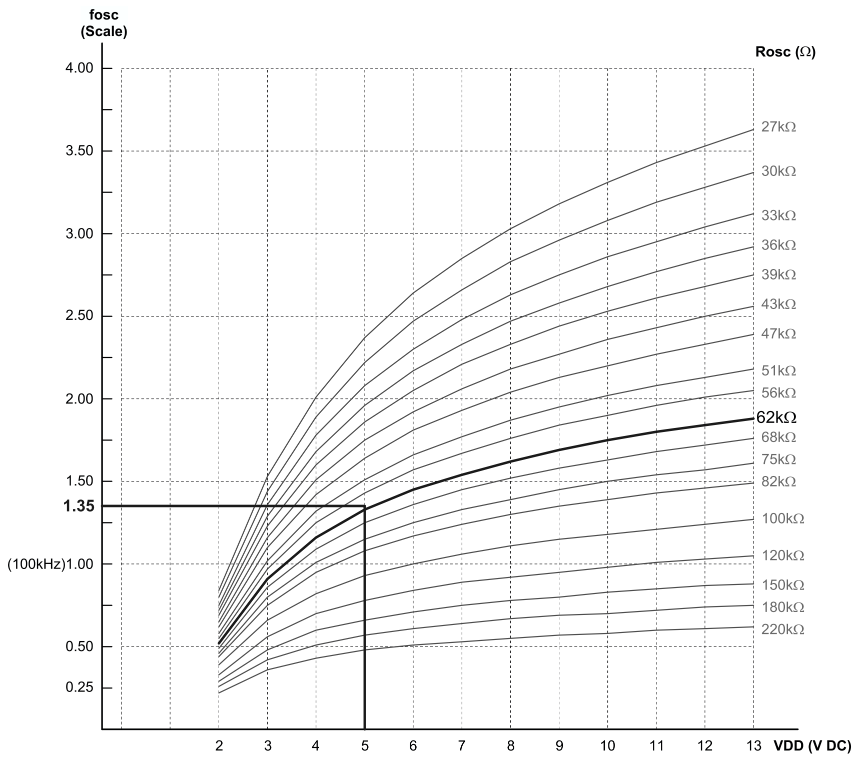

Fig. 3.14: Plot of Oscillator frequency vs supply voltage for HT12D

3.4.3 Switching circuit

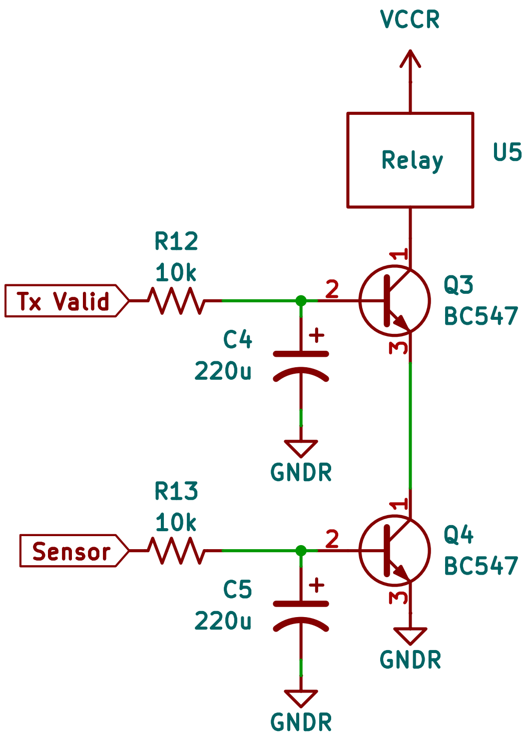

Fig. 3.15: Switching circuit

The switching circuit shown in Fig 3.15 is designed such that the relay is only turned on when both the sensor data as well as the valid transmission, VT, is high. To achieve this two transistors are placed in an AND gate configuration. The transistors are cascaded so that both of them have to be biased (by VT and D8) for the relay to turn on.

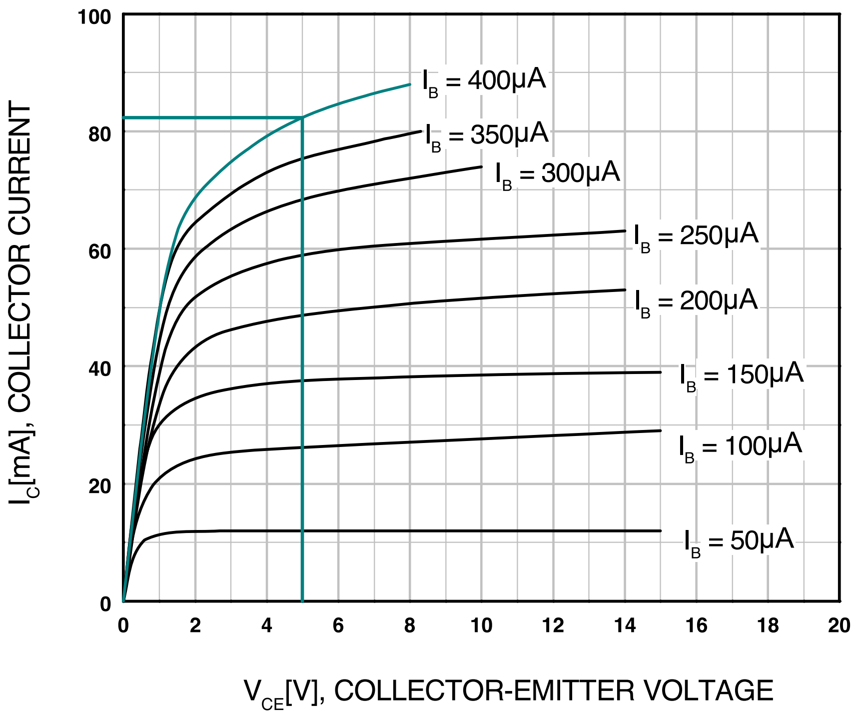

Fig. 3.16: Plot of CE voltage vs collector current for BC547

The relay needs 5V to operate, and its coil has a resistance of 60Ω. Therefore the current flowing through should be around 80mA. This means that the transistor must allow at least 80mA or more. From the V_{CE} vs I_C plot shown in Fig 3.16, it can be inferred that a base current of 400uA and more should be applied. The output voltage from the decoder IC is 5V. To get the desired 400uA at the base, a resistance can be connected in series. The resistor value is calculated to be 12kΩ. Therefore, a lower value of 10kΩ is chosen for the base resistor. It was noticed during irrigation the relay would occasionally flicker due to noise in the communication. To eliminate this, a capacitor of 220uF is placed in the base of the transistors, effectively acting as a low pass filter.

3.5 PCB Layout

PCB layout is shown in Fig 3.17. The layout was created in a way that reduces the PCB size as much as possible. The receiver part was the most challenging as there were multiple signals that has to be routed while avoiding short circuit.

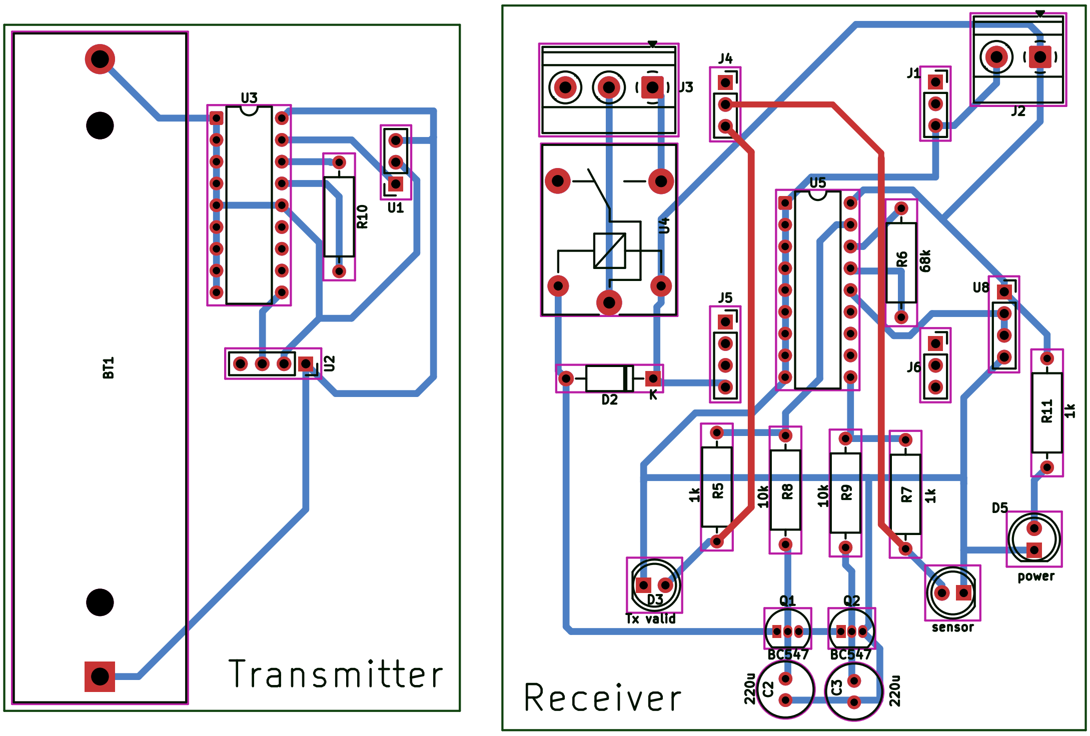

Fig. 3.17: PCB Layout

Chapter 4
Bill of materials

Sl. no	Component	Quantity	Unit Price	Cost
1	NodeMCU (esp32)	1	430	430
2	Soil moisture sensor module	1	34	34
3	HT12E RF Encoder	1	62	62
4	HT12D RF Decoder	1	62	62
5	1N4007 diode	1	2	2
6	BC547B NPN transistor	2	3	6
7	LED	4	2	8
8	Resistors	7	0.5	3.5
9	3 pin PCB mount terminal block	1	8	8
10	Perf board	1	20	20
11	Type C panel mount female connector	1	1	12
12	FS100A 433MHz Tx Rx pair	1	75	75
13	SPDT relay	1	17	17
14	18650 Rechargeable Battery	1	116	116
15	18650 battery case	1	27	27
16	DC pump	1	51	51
Total				**₹933.5**

Table 4.1: Bill of materials

Chapter 5
Results and Discussion

With this project we successfully implemented an automatic irrigation system enabling efficient water management through remote monitoring and wireless communication. By using a soil moisture sensor, the system monitored the moisture level of soil and supplies water when soil was dry. The status was also indicated on a LED on the board. The level of soil moisture had to set through potentiometer on the soil moisture sensor. It took multiple attempts to tune the sensor properly.

The use of high capacity rechargeable battery in transmitter allows a sustainable way to operate the device. Also the battery can run for months at a stretch hence reducing maintenance labour. In the receiver, 5V supply is needed for the operation. For this a USB type-C connector was utilized so that any 5V adapter such as phone charger can be utilized for the product. Thus user can use old phone chargers to operate the device increasing ease of use. This reduces cost of the product as a separate power supply need not be included with the product. Additionally a simple voltage limiting circuit can be utilized to reduce damage caused by sudden voltage fluctuation in case the adapter fails. Fig 5.1 shows the Prototype of the transmitter and receiver created in perf board.

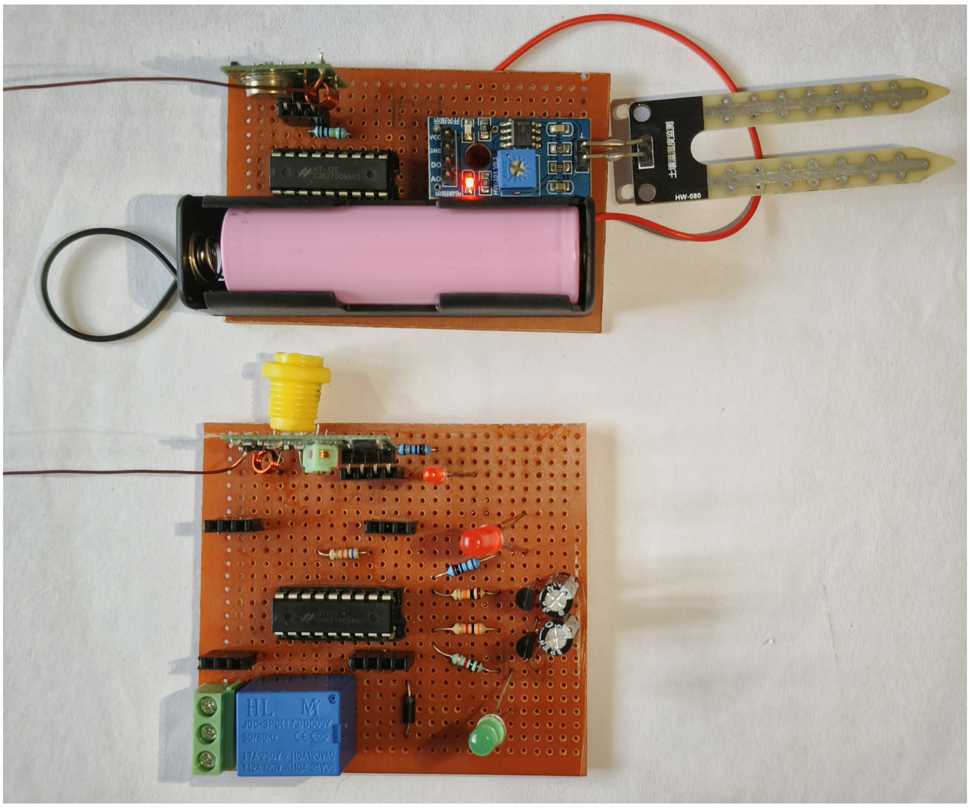

Fig. 5.1: Prototype of the transmitter and receiver section

A web interface was also developed which displays the status of connectivity between radio modules, soil moisture and state of the pump. The site also includes a logging feature to check the past activity of the pump. This data is retained throughout the runtime of the NodeMCU. The site will be automatically refreshed every 3 seconds and fetches the data from the sensors. Fig 5.2 Shows the designed web page.

Fig. 5.2: Web interface showing status of the system

One issue is that the address of the webpage has to be obtained from NodeMCU. With the current prototype it can be done either by mapping the network or connecting NodeMCU to a computer and reading the USB Serial output as shown in Fig 5.3. Here connecting NodeMCU to a Wi-Fi network is done by manually storing Wi-Fi credentials inside the NodeMCU.

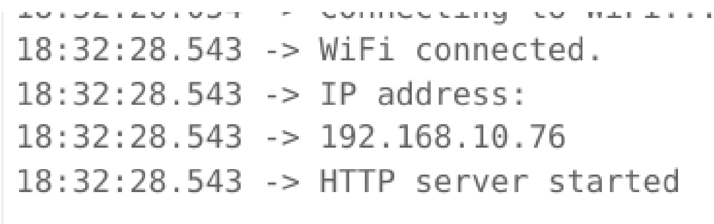

Fig. 5.3: USB Serial Output

Chapter 6
Limitations & Future Scope

6.1 Limitations

Currently the Project is not fully ready for production purposes. Listed below are few limitations of the current implementation. These can be considered as a part of future improvement.

1. **Limited Wireless Range**
   The current system's wireless transmission is limited to approximately 10 meters, restricting its application in large-scale agricultural settings without signal amplification or alternative communication technologies.

2. **Environmental Protection**
   The prototype lacks comprehensive weatherproofing, making it vulnerable to malfunction during rainfall or in high-humidity environments, potentially damaging exposed electronic components.

3. **Feedback Mechanisms**
   The system includes a basic feedback mechanism where the soil moisture status is read by the NodeMCU and updated in real time on a hosted website. However, it currently lacks a dedicated feedback method to confirm the successful execution of control commands such as verifying whether the pump has actually turned on when triggered which can limit reliability in remote monitoring or automation scenarios

4. **Monitoring Capabilities**
   The current version monitors only soil moisture levels. Incorporation of additional environmental parameters (temperature,humidity,pH) would enhance decision-making capabilities and system versatility.

6.2 Future scope

1. **Create an enclosure**:
   Since the system operates in an external agricultural environment, exposure to dust, soil and moisture is inevitable. A well sealed-enclosure prevents water damage and dust accumulation ensuring smooth working of sensitive components.

2. **Integrating additional sensors**:
   Sensors such as temperature, humidity, light, pH sensors etc. can be helpful in optimizing irrigation and also helps in gathering information about environment of farmland

3. **Extending range of radio system**:
   Currently the system can operate at a range of 10m. However the module itself can transmit at a maximum range of 100m. This can be improved by using better antennas. Moreover, there are newer versions of the radio modules that are more reliable.

4. **Improving feedback mechanism**:
   Creating a mechanism to check the actual status of the motor is useful for troubleshooting.

5. **Improving Wi-Fi connectivity**:
   In the current implementation the Wi-Fi credentials have to be manually embedded into NodeMCU. This could be avoided by using an application that creates secure Wi-Fi Hotspot and enabling NodeMCU to connect to Wi-Fi.

6. **Using cheaper alternative to ESP32**:
   ESP32 has more features such as bluetooth which are redundant and contributes to increased idle current. Alternatives to ESP32 such as ESP8266 can be employed in this case

7. **Remote control**:
   If needed, the user can optionally turn on the motor remotely. This is useful in cases where the user has prior knowledge of possible power supply failure later in the day. Hence user can water plants in advance.

Chapter 7
Conclusion

This project successfully demonstrates the feasibility and benefits of sensor-based automation in irrigation systems. Despite certain limitations, the system provides a foundation for sustainable and cost-effective farming practices and efficient water management.

The designed and implemented automatic irrigation system is capable of monitoring soil moisture levels and automating irrigation based on real-time data. By integrating components such as a soil moisture sensor, RF communicating modules, we created a system that responds intelligently to the soil's hydration needs. When the moisture level drops below a preset threshold, the system activates the water pump, ensuring plants receive optimal watering without manual intervention. The use of standard connectors such as USB type C make the system portable and makes it easy to use.

The system created stands as a practical example of how technology can be utilized to address real-world agricultural challenges. While future iterations could address the current limitations, the existing system already demonstrates potential for reducing manual labor and optimizing resource utilization in small-scale agricultural applications.

References

[1] A. Gupta *et al.*, ”On-Farm Irrigation Water Management in India: Challenges and Research Gaps,” *Irrigation and Drainage*, vol. 71, no. 1, pp. 152–162, 2022. Available: https://doi.org/10.1002/ird.2637

[2] S. Kanthal, S. Kundu, and A. Chatterjee, ”Progress and Difficulties with Micro-Irrigation,” *Int. J. Agric. Ext. Soc. Dev.*, vol. 7, no. 4, pp. 18–21, 2024. Available: https://doi.org/10.33545/26180723.2024.v7.i4a.497

[3] ”Irrigation Governance in Developing Countries: Current Problems and Solutions,” *Water*, vol. 10, no. 9, pp. 1118–1135, 2018. Available: https://doi.org/10.3390/w10091118

[4] ”Electronics For You Express,” vol. 13, no. 2, p. 56, Feb. 2021. Available: https://online.fliphtml5.com/oxomv/fjlb/

[5] FS1000A RF Module, ”433MHz RF Transmitter and Receiver Pair,” Datasheet. Available: https://robu.in/wp-content/uploads/2016/05/FS1000A-datasheet.pdf

[6] Holtek Semiconductor Inc., ”HT12E 212 Series of Encoders,” Datasheet. Available: https://www.farnell.com/datasheets/1899539.pdf

[7] Holtek Semiconductor Inc., ”HT12D 212 Series of Decoders,” Datasheet. Available: https://www.farnell.com/datasheets/57850.pdf

[8] Fairchild Semiconductor, ”BC547 NPN General Purpose Transistor,” Datasheet. Available: https://cdn.sparkfun.com/assets/d/5/e/5/d/BC547.pdf

[9] Yueqing Hengwei Electronics, ”JQC-3FC(T73) Sugar Cube Relay,” Datasheet. Available: https://pdf.voron.ua/files/pdf/relay/JQC-3F(T73).pdf

[10] Quartz Components, ”3V to 9V Mini DC Submersible Pump”. Available: https://quartzcomponents.com/products/3v-to-12v-mini-dc-submersible-pump

[11] Espressif Systems, “ESP32 Series Datasheet,” Version 4.9. Available: https://www.espressif.com/sites/default/files/documentation/esp32_datasheet_en.pdf

Appendix

Source code for web server

```
#include <WiFi.h>
#include <WebServer.h>

const char* ssid = "home";
const char* password = "psw@shell12";

WebServer server(80);

String pumpStatus = "OFF";
String pump = "OFF";
String logData = "";

void handleRoot() {
  int sensor1=digitalRead(32); //valid transmission
  int sensor2=digitalRead(35); //moisture

  String vt = sensor1==1 ? "Connected" : "Disconnected";
  String moist = sensor2==1 ? "Dry" : "Wet";

  if (sensor1==1 && sensor2==1) {
    pump = "ON";
  } else {
    pump = "OFF";
  }

  server.send(200, "text/html",
  "<meta http-equiv='refresh' content='3'>"
  "<script>"
    "function updateTime() {"
    "  const now = new Date();"
    "  document.getElementById('timestamp').innerText = 'Last
     ↪ updated: "
```

```
    "' + now.toLocaleString();"
    "}"
    "window.onload = updateTime;"
  "</script>"
  "<h1>Status: " + vt + "</h1>"
  "<h1>" + moist + " soil</h1>"
  "<h1>Pump: " + pump + "</h1>"
  "<p id='timestamp'></p>"
  "<pre>" + logData + "</pre>"
  );
}

void checkForChanges() {
  int sensor1 = digitalRead(32);
  int sensor2 = digitalRead(35);

  unsigned long now = millis();
  String timeStr = String(now / 1000) + "s since boot";

  if (pump != pumpStatus) {
    logData += "Pump turned " + pump + " at " + timeStr +
     ↪  "\n";
    pumpStatus = pump;
  }

  if (logData.length() > 2000) {
    logData = "Log trimmed...\n" +
      logData.substring(logData.length() - 1000);
  }
}

void setup() {
  pinMode(32, INPUT);
  pinMode(35, INPUT);

  Serial.begin(115200);
```

```
  WiFi.begin(ssid, password);
  Serial.print("Connecting to WiFi..");

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }

  Serial.println("");
  Serial.println("WiFi connected.");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());

  server.on("/", handleRoot);

  server.begin();
  Serial.println("HTTP server started");
}

void loop() {
  checkForChanges();
  server.handleClient();
}
```