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 project report entitled **"Automatic Irrigation System"** is a bonafide work of **Roopesh O R, Roshna Palatty Santhosh, Sumayya Punnoth and 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.*

Project Co-ordinator

Head of Division
Dr. Deepa Sankar

Acknowledgment

We express our indebtedness in God Almighty for the successful completion of our project. First and foremost, we express our gratitude to Dr. Deepa Sankar, Head of the Division of Electronics and Engineering. We would like to thank our project guides .... for guiding us in our project and providing us with adequate facilities in order to complete the task we had undertaken. Our sincere gratitude is expressed and extended to our lab staff and other faculty members of the Electronics and Communication Division for their assistance and unwavering support. We proudly thank all our friends who helped us in various stages of this endeavor

Abstract

This project details the design and implementation of an automatic irrigation system with remote monitoring, addressing the critical need for efficient water management in agriculture. The system consists of a Transmitter, Receiver, Soil Moisture Sensor, NodeMCU, Encoder, Decoder, Relay and Motor. The transmitter utilizes a soil moisture sensor to continuously monitor the moisture level of soil, encodes and transmits the data. The receiver receives this data, decodes and activates the motor through a relay which pumps the water till the threshold water level is reached. This data can be accessed through a webpage hosted by NodeMCU.

Table of contents

List of Figures

List of Tables

Chapter 1
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, and salinity buildup, affecting both crop yield and soil health [1].

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 leveraging microcontrollers and wireless communication modules, such systems can operate remotely and autonomously with minimal human intervention [2, 3]. Studies have demonstrated that low-power and modular designs, like those using NodeMCU and RF modules, offer a promising balance between affordability, scalability, and effectiveness, especially in resource-constrained agricultural settings [4].

In countries like India and Ethiopia, large-scale public irrigation systems suffer from poor infrastructure, lack of maintenance, and inefficient water governance, which further diminishes the effectiveness of these systems [5]. Furthermore, centralized systems lack adaptability to local soil and crop conditions and do not leverage modern sensing or automation technologies.

Recent literature emphasizes the need for *automated irrigation systems* that incorporate real-time soil moisture sensing and remote control mechanisms. Such systems have been proposed as a solution to reduce manual labor, optimize water use, and improve yield consistency [6]. However, challenges remain in terms of affordability, scalability, and power efficiency for small and marginal farmers.

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

Chapter 2
Introduction

Efficient Irrigation is very crucial in modern agriculture for maximizing both production and profit. Water scarcity and inefficient irrigation practices pose significant challenges. Traditional irrigation methods often lead to overwatering or underwatering, resulting in poor crop yield and excessive water consumption. With the increasing demand for sustainable farming solutions, automated irrigation systems provide an efficient way to optimize water usage while ensuring healthy plant growth.

The Automatic Irrigation System automates plant watering based on real-time soil moisture levels. The system uses 433MHz RF for wireless communication. In the transmitter unit the soil moisture sensor continuously measures whether the moisture content in the soil is above or below a set reference and produces a corresponding digital signal. Then an encoder (HT12E) encodes this data in the transmitter unit and transmits it using an RF transmitter module. The data is received and decoded at the receiver unit and according to the received data the receiver unit activates a relay, turning on a water pump to irrigate the soil. Once the moisture level reaches the desired value, the transmitter detects this change and sends an update to the receiver, which then deactivates the relay, switching off the pump. This data can be accessed through a webpage hosted by a NodeMCU. This system ensures efficient water management, reducing wastage and minimizing manual intervention, making it an ideal solution for smart agriculture.

Chapter 3

Design

3.1 Block diagram

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

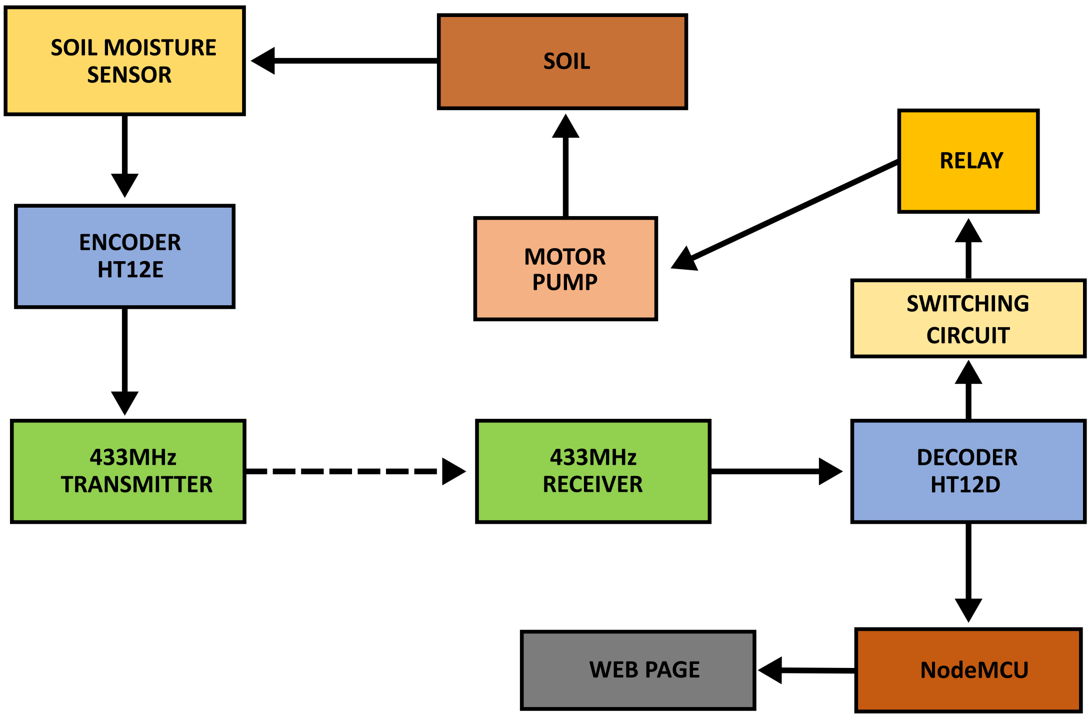

Fig. 3.1: Block Diagram

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 soil moisture status is read by NodeMCU and updates the status on a website hosted in NodeMCU

3.2 Components

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 water. 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

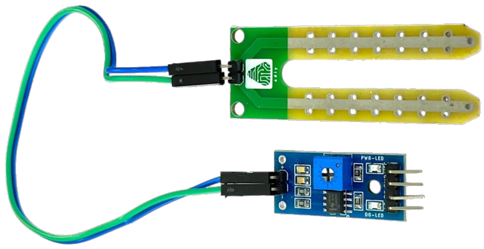

Fig. 3.2: Soil moisture sensor

3.2.2 FS1000A: Transmitter & Receiver module

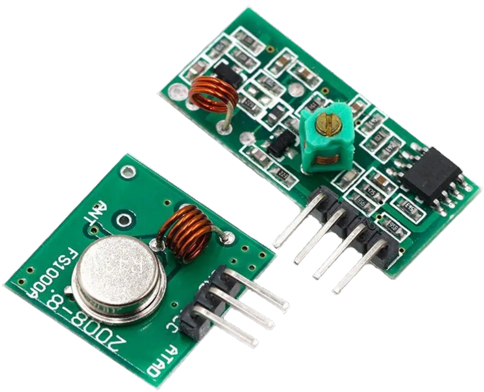

Fig. 3.3: FS1000A receiver & transmitter pair

This 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.

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

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

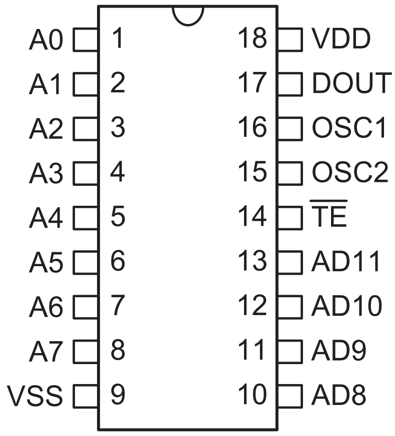

Fig. 3.4: HT12E encoder IC pinout

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.

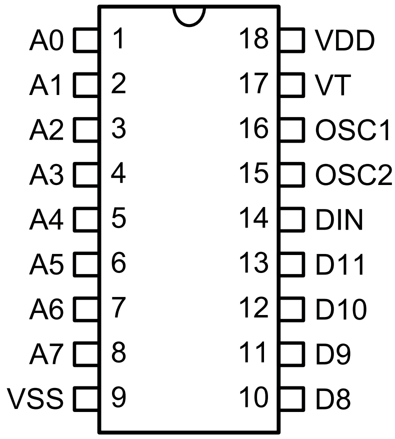

Fig. 3.5: HT12D decoder IC pinout

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.

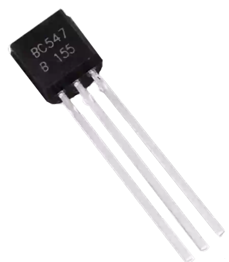

Fig. 3.6: BC547 transistor

3.2.6 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. This battery was chosen at the transmitter circuit as it can power the circuit for months without recharge in (ideal conditions)

Fig. 3.7: 18650 battery and its holder

3.2.7 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

Fig. 3.8: PCB Mount Relay

3.2.8 DC Motor Pump

We used a 6V DC motor pump to supply water to the field. The motor consumes 4-5W of power. The motor can work from 3V to 6V. It can supply water up to a height of 110cm at maximum operating voltage. For the purpose of demonstration, the motor is powered by a regulated power supply that can supply 5V DC

Fig. 3.9: DC motor pump

3.2.9 NodeMCU

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 Wifi 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 appropriate signal conditioning to match sensor output characteristics. The module can be powered using an external supply through its micro USB port or with 5V and GND pins in the board

3.3 Circuit Diagrams

3.3.1 Transmitter

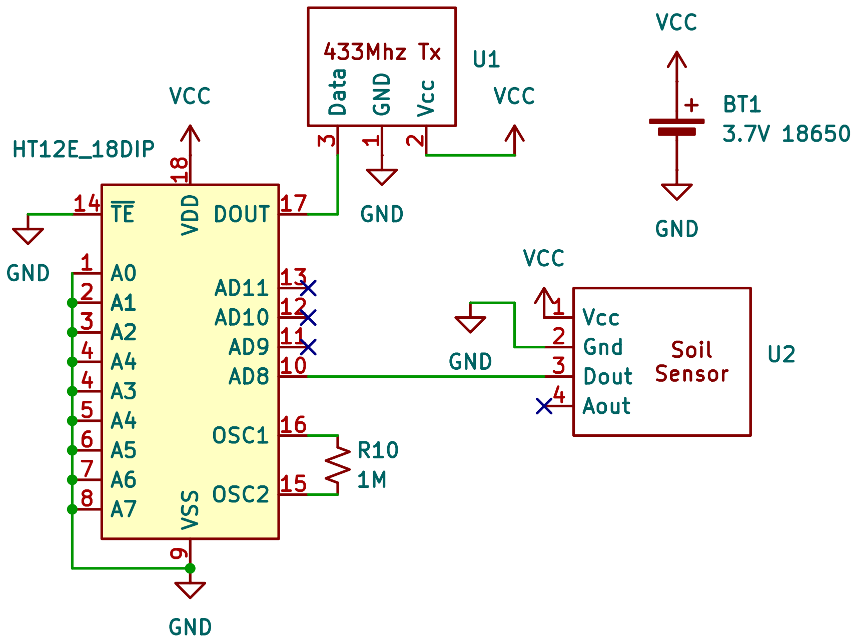

Fig. 3.10: Transmitter circuit

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.

3.3.2 Receiver

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

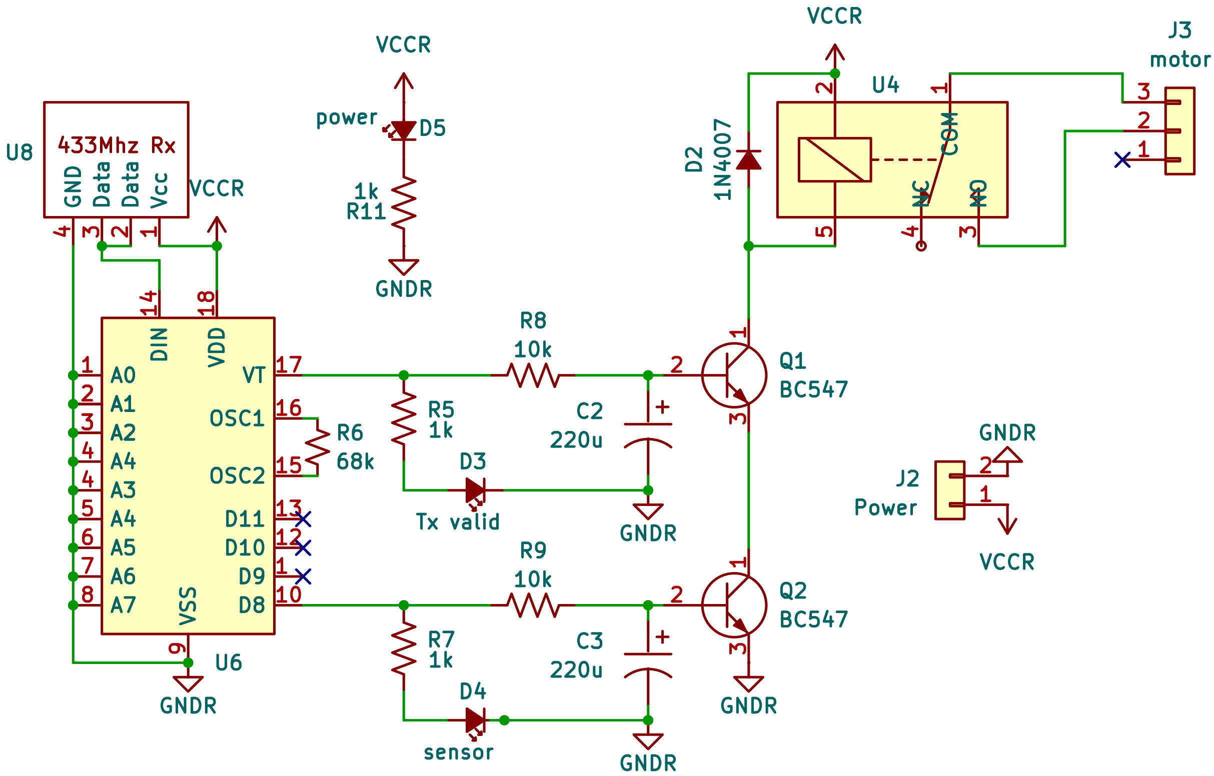

Fig. 3.11: Receiver circuit

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.

3.4 Tuning circuit parameter

3.4.1 Encoder IC oscillator

The encoder is powered by a voltage supply of 3.7V. An arbitrary value of 1MΩ 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, the oscillation frequency corresponding to the particular resistance and voltage values is seen to be 2.71kHz.

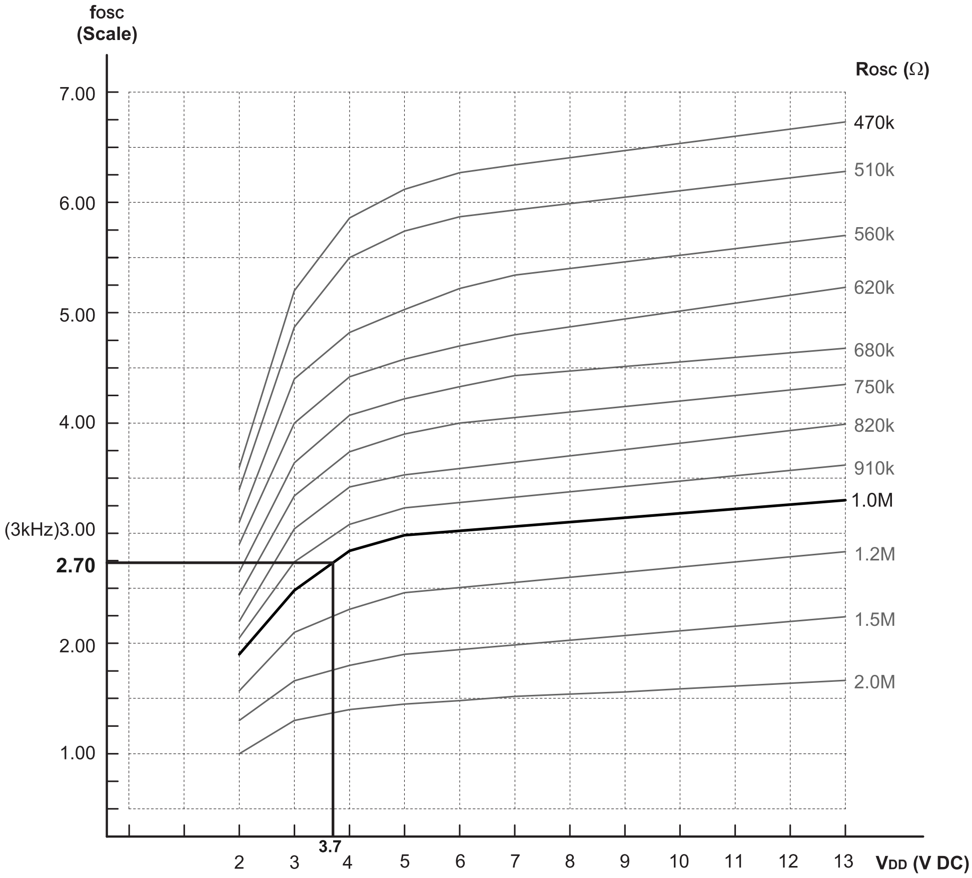

Fig. 3.12: Plot of Oscillator frequency vs supply voltage for HT12E

3.4.2 Switching circuit

The switching circuit 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.

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 IC vs VCE graph, 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, the base resistor is chosen to be 10kΩ.

It was noticed that during transmission, during irrigation the relay would occasionally flicker due to some 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.

3.4.3 Decoder IC oscillator

The recommended oscillator frequency for the decoder is 50 times that of the encoder's frequency. In this case it has to be 135kHz. The decoder is powered by a voltage supply of 5V.

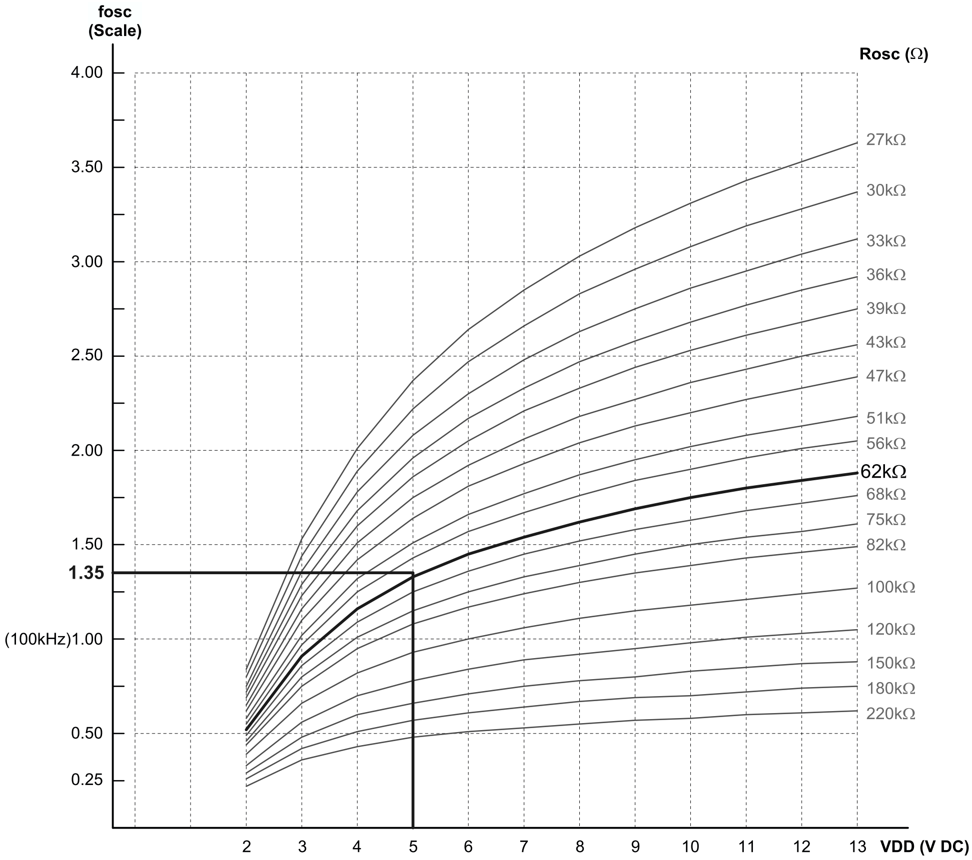

Fig. 3.13: Plot of Oscillator frequency vs supply voltage for HT12E

From the Oscillator Frequency vs Supply Voltage graph of the decoder, it can be seen that the resistor value corresponding to a 5V supply voltage and calculated oscillation frequency (135kHz) is 62kΩ. The nearest resistance value which we had was 68kΩ and we proceeded to use it Upon testing, we fount that this slight change did not had much deteoration in the communication system. This resistor is connected across the pins OSC1 and OSC2 (pins 16 and 15).

3.5 PCB Layout

3.6 Assembled circuit

Chapter 4
Results & Conclusion

With this project we have successfully implemented an automatic irrigation system enabling efficient water management through remote monitoring and wireless communication. By using a soil moisture sensor, the system monitors the moisture level of soil and supplies water based on soil conditions. This ensures optimal plant hydration reducing manual labour and water wastage. The system not only optimizes water usage but also promotes sustainable growth by preventing overwatering and underwatering.

Chapter 5
Limitations & Future Scope

5.1 Limitations

Currently the maximum range of stable transmission is 10 meters. This could be further improved by proper designing of antennas. This could also avoid cases where transmission can occasionally halt for a brief time. Also the system can fail during precipitation due to limited waterproofing.

5.2 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 based and also helps in gathering information about environment of farmland

3. 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.

4. Using drip irrigation and recycling of water:
   In drip irrigation water is supplied to the roots of plants drop by drop. This can further reduce wastage of water through evaporation or runoff

Chapter 6
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 6.1: Bill of materials

References

1. "Electronics For You Express", february 2021 edition, page 56 - https://online.fliphtml5.com/oxomv/fjlb/

2. HT12E data encoder - https://www.farnell.com/datasheets/1899539.pdf

3. HT12D data decoder - https://www.farnell.com/datasheets/57850.pdf

4. BC547B NPN transistor - https://cdn.sparkfun.com/assets/d/5/e/5/d/BC547.pdf

5. FS1000A radio transmitter and receiver - https://robu.in/wp-content/uploads/2016/05/FS1000A-datasheet.pdf

6. JQC-3FC(T73)DC05V sugar cube relay https://pdf.voron.ua/files/pdf/relay/JQC-3F(T73).pdf

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. [Online]. 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. [Online]. Available: `https://doi.org/10.33545/26180723.2024.v7.i4a.497`

[3] E. K. Kanda and V. O. Lutta, "The Status and Challenges of a Modern Irrigation System in Kenya: A Systematic Review," *Irrigation and Drainage*, vol. 71, no. 4, pp. 752–765, 2022. [Online]. Available: `https://doi.org/10.1002/ird.2700`

[4] J. Nair and B. K. Thomas, "Why Is Adoption of Micro-Irrigation Slow in India?" *Development in Practice*, vol. 33, no. 1, pp. 96–108, 2023. [Online]. Available: `https://doi.org/10.1080/09614524.2022.2059065`

[5] "Review on Irrigation Development and Management Practices in Ethiopia," *Agricultural Water Management*, vol. 271, 2022. [Online]. Available: `https://doi.org/10.1016/j.agwat.2022.107959`

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

Appendix