University of Mumbai

LoRa based Smart Irrigation system using IoT

Submitted at the end of semester VII in partial fulfillment of requirements

For the degree of

Bachelors in Technology

by

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Abstract

Since the world's population has surpassed 7.2 billion and is continuing to grow at a steady rate, there will be a serious food shortage over the next 25 to 30 years, making agricultural advancements essential. Farmers are currently dealing with a water deficit and the absence of downpours. This paper's main objective is to provide a smart irrigation system that will allow farmers to save time, money, and electricity. The prototype employs an RFM98w-sx1278 LoRa module in the smart valve and two Atmel's Atmega328p as the controller for the moisture sensor. Data on moisture, temperature, humidity, and water levels are transmitted over the internet by the moisture sensor and smart valve and may be accessed via a web or mobile application. In order to automatically start pumping water into the fields, the data is evaluated. Manual trigger application is another option.

***Key words*:** Lora, smart farming, IoT, sensors.

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Nomenclature

IoT Internet of Things

LoRa Long Range

IDE Integrated Development Environment

IPE Integrated Programming Environment

WAN Wide Area Network

API Application Programming Interfaces

CPU Central Processing Unit

WSN Wireless Sensor Network

PWM Pulse Width Modulation

ADC Analog to Digital Converter

PCB Printed Circuit Board

Chapter 1

Introduction

The project's background, the inspiration behind our decision to focus on this particular subject, the project's scope, and a brief explanation are all provided in this chapter.

1.1 Background

The concept of "smart irrigation" has emerged as a groundbreaking solution in response to the challenges faced by the agricultural industry. This innovative approach, currently in the developmental phase, holds tremendous potential from economic, social, and traditional perspectives, especially in regions where water resources are scarce. The primary goal of developing intelligent irrigation systems has been to reduce manual labor, conserve water and energy, and improve overall efficiency. However, there remains a pressing need for an advanced irrigation system that can assist farmers in maximizing crop quantity and quality, especially given the increasing demand for food due to population growth.

Farmers have been grappling with numerous challenges, ranging from crop quantity and quality to water scarcity, necessitating a comprehensive solution. While smart irrigation has made significant strides, accurately estimating water flow remains a significant obstacle. Consequently, our project is focused on developing an irrigation system that not only encompasses the aforementioned benefits but also integrates the standard functionalities found in smart water systems. These standard functionalities include the precise estimation of the field's moisture profile to prevent waterlogging and the integration of temperature detection to account for the plants' sensitivity to temperature fluctuations. To achieve reliable measurements of these critical factors, our project relies on the deployment of a diverse array of sensors strategically placed throughout the field.

By leveraging these sensors, our irrigation system gathers real-time data on soil moisture levels and temperature, enabling informed decision-making. This data-driven approach ensures that water is delivered precisely when and where it is needed, avoiding both overwatering and under-watering scenarios. By optimizing irrigation schedules and utilizing resources efficiently, farmers can conserve water, minimize energy consumption, and ultimately enhance crop yields.

The integration of these sensors and the seamless incorporation of their data into our irrigation system revolutionize traditional farming practices. This intelligent system enables precise monitoring and control, transforming irrigation into a highly efficient and automated process. The collected data serves as a valuable resource for analysis, enabling farmers to make informed decisions and fine-tune their irrigation strategies to suit specific crop requirements.

The development of our advanced irrigation system, which combines the benefits of smart irrigation with the integration of standard functionalities, represents a significant step forward in addressing the challenges faced by farmers. By accurately estimating water flow, monitoring soil moisture profiles, and incorporating temperature detection, our system offers a comprehensive solution to optimize irrigation practices. Through the deployment of a network of strategically positioned sensors and data-driven decision-making, farmers can achieve efficient water utilization, mitigate the risk of waterlogging, and create an optimal environment for crop growth. Embracing this intelligent approach empowers farmers to enhance agricultural practices, improve crop yields, and contribute to sustainable food production in an increasingly resource-constrained world.

The advent of smart farming is poised to usher in a new era of agriculture, offering the promise of increased crop yield, cost reduction, and enhanced convenience. However, despite the undeniable potential, farmers remain cautious about embracing smart farming due to concerns surrounding the high upfront costs, inefficient energy utilization, complex management requirements, and potential data security vulnerabilities. While numerous studies highlight the advantages of LoRa (Long Range) technology, a type of LPWAN (Low Power Wide Area Network) known for its long-range capabilities, affordability, and low power consumption, they often overlook the critical aspects of data transfer efficiency, security, and reliability.

Taking these concerns into account, our dedicated research team proposes the development of the LM Farmâa smart and intelligent farm that leverages the synergy of LoRa and MQTT (Message Queue Telemetry Transport) technology. MQTT, renowned for its lightweight communication protocol, not only ensures secure and reliable data transfer but also minimizes the wastage of valuable packet space, optimizing network efficiency.

The incorporation of LoRa technology within the LM Farm unlocks a host of benefits. With its long-range capabilities, LoRa enables seamless connectivity over vast agricultural landscapes, eliminating the need for extensive infrastructure deployment. Additionally, its cost-effectiveness and low energy requirements make it an ideal choice for resource-constrained farming operations, enabling farmers to reap the rewards of smart farming without incurring exorbitant expenses. By harnessing the power of LoRa, the LM Farm establishes a robust and dependable network for data transmission, empowering real-time monitoring and control of various crucial farm parameters.

However, the reliability and security of data transfer are of utmost importance in smart farming systems. This is where the integration of MQTT becomes paramount. The lightweight nature of MQTT minimizes communication overhead, optimizing network resources and facilitating efficient and seamless communication between devices and the central farm management system. Moreover, MQTT's strong emphasis on data security ensures that sensitive farm information remains shielded from unauthorized access, safeguarding against data breaches and preserving the integrity of farm operations.

The holistic integration of LoRa and MQTT within the LM Farm addresses the reservations voiced by farmers regarding smart farming technologies. This intelligent farm system not only boosts operational efficiency and optimizes resource utilization but also empowers farmers with real-time data insights for informed decision-making. Furthermore, the robust data transfer facilitated by MQTT instills confidence in farmers, assuring them that their valuable data remains private and protected throughout the communication process.

The pioneering LM Farm serves as a testament to the transformative potential of LoRa and MQTT technologies in revolutionizing the agricultural landscape. By directly addressing the concerns of farmers and prioritizing factors such as data security, reliability, and efficiency, the LM Farm sets a benchmark for future smart farming implementations. Through the seamless integration of advanced technologies and a comprehensive approach to data transfer, the LM Farm paves the way for sustainable and successful adoption of smart farming practices, ultimately leading to increased productivity, reduced costs, and improved agricultural outcomes.

A variety of gadgets, including the ESP8266, Arduino, ZigBee, GSM, GPRS, and smartphone, were presented for smart irrigation approaches. Without connecting to the internet, ESP8266 was utilised as an extension of Arduino to transfer the data over the WiFi protocol. The price of GPRS and GSM was higher. The ZigBee protocol is no longer used. Because the LoRa protocol employs an unlicensed frequency, data transmission and reception are less expensive. The ESP32 TTGO, which is connected to the Internet, can be used to connect a variety of TTGO boards, enabling remote operation of the system from anywhere in the globe.

1.2 Motivation

The great majority of irrigation systems that are in use today still need the use of human work in order to be operated. These archaic practises have been phased out and replaced with automated and semi-automated processes as part of an ongoing effort to modernise the organisation. Irrigating land and watering crops using these tried-and-true methods, such as drip irrigation, sprinkler systems, ditch irrigation, and terraced irrigation, are sure to provide the best results. The problem of irrigation across the globe may be broken down into many different aspects, such as the expanding need for increased agricultural productivity, the inability to fully implement solutions, and the shrinking availability of water for agricultural use. The installation of intelligent irrigation systems will make it possible for us to address these problems and develop solutions to them. Both Professor Kirti Sawlani and Professor Amrita Naiksatam acted as the report's supervisors throughout its final stages of production. The production of this report went quite smoothly as a result of their aid and guidance, which is why it was so successful.

1.3 Scope of project

Rice stands as a fundamental dietary component for numerous Asian nations, serving as a primary source of nutrition. These countries, with economies heavily reliant on agriculture, recognize the pivotal role of irrigation in sustaining their agricultural industry. The impact of irrigation extends beyond crop yield, directly influencing overall production output. In this context, the integration of an Internet of Things (IoT)-based smart irrigation system, utilizing the long-range (LoRa) network, emerges as a transformative design aimed at fostering smart agriculture nationwide. The purpose of this article is to address the imperative of enhancing agricultural efficiency on a countrywide scale.

The envisioned system embraces the power of IoT-connected sensors to gather precise

Figure 1.1: Manual farming

data from paddy fields, seamlessly transmitting and storing the information on a cloud-based server. A meticulously designed mesh-topological, low-power wireless network architecture serves as the foundation for deploying and monitoring various essential components, including weather stations, sensor nodes, and valve-control nodes. Moreover, the system incorporates the development of a controller node, playing a pivotal role in optimizing irrigation systems. By curbing water wastage, minimizing labor requirements, reducing financial burdens, and streamlining farming practices, the proposed solution capitalizes on the available resources.

The implications of the proposed IoT-based smart irrigation system extend far beyond agricultural efficiency. The immediate and overarching societal benefits are evident, as it has the potential to significantly increase both the quantity and quality of agricultural produce. Furthermore, the system holds promise as a solution to the global challenge of food scarcity, making a substantial contribution toward mitigating the issue at hand. Moreover, the underlying technological framework offers ample opportunities for additional applications built upon the same foundation, creating a ripple effect of innovation and progress.

To summarize, the introduction and adoption of an IoT-based smart irrigation system utilizing LoRa technology present a breakthrough approach to revolutionizing the agricultural landscape. By seamlessly integrating cutting-edge sensor technology, wireless connectivity, and cloud-based data management, the system aims to optimize irrigation practices, enhance resource efficiency, and ultimately elevate agricultural productivity. As the world faces escalating demands for food production, embracing innovative solutions like this becomes imperative in ensuring long-term food security and promoting sustainable agricultural practices on a global scale

1.4 Brief description

The system is composed of three distinct components, each contributing to the overall functionality and efficiency of the smart irrigation system. These components can be broken down into their individual parts, showcasing their unique roles and contributions. At the heart of the system lies a Raspberry Pi, which serves as both the power source and energy provider for the smart valve, soil moisture sensor, and LoRa transceiver. This central component ensures the seamless operation of the system by supplying the necessary power to all interconnected devices.

The LoRa transceiver module assumes a vital role in data management and communication within the smart irrigation system. It acts as a bridge between the sensor nodes and the user interface, responsible for recording, transmitting, and relaying the collected data to the end user. The transceiver module facilitates efficient communication by leveraging various communication channels such as dedicated applications, phone calls, or text messages. Moreover, it plays a crucial role in data storage, ensuring the availability of historical information for analysis and decision-making.

The soil moisture sensor takes on the responsibility of monitoring crucial soil parameters, including moisture content, humidity levels, and temperature. By accurately measuring and analyzing these variables, the sensor provides valuable insights into the soil's water requirements. It then transmits this information to the LoRa transceiver for further processing and dissemination. With this data, the system can make informed decisions regarding irrigation schedules, ensuring that water is applied only when necessary. This intelligent approach promotes water conservation practices and maximizes the efficient use of resources.

The inclusion of the smart valve adds an additional layer of control and efficiency to the system. Acting as a gatekeeper for water distribution, the smart valve responds to the information received from the soil moisture sensor. It autonomously adjusts the water flow based on the soil's moisture levels, thereby preventing over-irrigation and conserving water resources. The smart valve's adaptability and flexibility allow for precise and targeted irrigation, catering to the specific needs of different areas within the agricultural field.

The smart irrigation system incorporates three essential components: the Raspberry Pi as the power source, the LoRa transceiver module for data management and communication, and the soil moisture sensor along with the smart valve for accurate monitoring and efficient water distribution. Through seamless integration and collaboration, these components work in harmony to optimize irrigation practices, conserve water, and enhance agricultural productivity. The unique functionalities they bring ensure the system's adaptability, reliability, and sustainability in promoting smart farming practices.

1.5 Organization of report

The undertaking was carried out at a cost that was affordable and was made available to all categories of end customers. As a result, the objective of this project is to create an Internet of Things (IoT)-based and LoRa-based smart irrigation system that would continually monitor the soil and inform the user in the event that any potentially hazardous circumstances exist. The remaining parts of the work are organised in the following manner: A literature survey is broken down and discussed in chapter 2. In Chapter 3, we will go through the design of the project, and in Chapter 4, we will look at how it was put into action. The report comes to a close with the discussion included in Chapter 5.

Chapter 2

Literature survey

This chapter offers a literature survey that cites specific sources from the sources listed in the bibliography.

We may use a range of sensors to provide the farmer with information about the field utilising a smart irrigation system. The sensors utilised are a soil moisture sensor, a temperature sensor, and a water flow sensor, which can compute how much water is used and prevent waterlogging issues for the crops. Crops are also temperature-sensitive. Because of this, IBM Watson and the farmer are aware of the system and are able to save the crop by turning on sprinklers or a water pump. [1]

With the technology outlined, temperature, soil moisture, and water level may all be automatically monitored. This system [2]may also be used with two sensor nodes, each of which has four sensors: one for subterranean water, one for soil moisture, one for pH, and one for water level. It may also be utilised with two weather stations, four paddy field water control gates and two canal water control valves. Fig. 1 depicts a high-level perspective of the proposed smart irrigation system design. The soil moisture, water level, and temperature sensors were all controlled by this system. Utilising LoRa technology, information from the sensors at the Inlet node, Outlet node, and Weather Station will be sent to the NECTEC server. The entrance and exit nodes may be seen. Sensors are used to detect water level, soil moisture, pH, temperature, and pressure in drainage canals, fields, sensor levels, and solar power supplies. Additional exits are provided by fields, irrigation canals, and the Solor power system. GSM signal strength, barometric pressure, humidity, light, rain, temperature, wind direction, wind speed, and solar power source may all be determined by weather stations. The controller receives the gathered data and transmits them on to the NECTEC server. On the cloud server, the data table may be accessible as data sets and viewed. After the data has been analysed, the Watergate will be run according to the amount of water needed.

The design of an autonomous monitoring and control system for greenhouse farming was covered in length in the article[3], along with specifics on the system's general architecture and the designs of the hardware and software of each component. The remaining problems from several past research, such as wireless network range and reliability, system functioning, and irrigation mode variety, were addressed in this study using LoRa technology. Along with the Master/Slave medium access control mechanism, we also employed LoRa technology. Additionally, a Web Interface that enables remote system control and monitoring has been developed. One Concentrator, two Sensor Nodes, two Control Nodes, one Local Database User Interface, and one Web Server make up the test system (Ubidots) that we successfully constructed. On the grounds of the Hanoi University of Science and Technology, the tests were carried out. The Cordinator is thus around 350 metres away from the End Devices. In order to regulate irrigation for the regions where the soil moisture sensors of the Sensor Nodes are positioned, the regulate Nodes were linked to the pump (12VDC) and the valves. The results of the trials show that the system works smoothly and acts as expected. The irrigation modes also function without any issues. Graphs depict irrigation for the experiment throughout a 24-hour period, both manually and automatically.

This paper [4] introduces LM Farm, a smart farm based on LoRa and MQTT. In terms of cost and power efficiency, LoRa performs better than other technologies while offering a larger coverage area. So it would make sense and be viable to choose LoRa as the network technology for smart farms. Additionally, in terms of data transfer dependability, security, and lightness, the MQTT protocol closes the gaps left by prior studies on smart farms. Although the concept proposed in this study tries to enhance past suggestions for smart farms, it still has a number of shortcomings. Due to the installation of TTN Cloud to run the LoRa gateway, an internet connection is now necessary. An ideal watering system would be able to function in any situation because outdoor internet connections aren't always reliable.

This research[5] examined the performance of LoRaWAN for a smart irrigation scenario with a range of parameters and presented a strategy based on simulation and measurement. According to our research, the LoRa air interface has the worst scalability issues, which are mostly caused by the quantity of sensors that are actively transferring data from a farm parcel to the gateway. The performance of the system as a whole is unaffected by the delay of the IoT Platform. Future research projects may benefit from using our testbed, especially the customised implementations. Therefore, in our next research, we will examine the outcomes of deploying LoRaWAN in a multi-gateway, bi-directional manner and utilise it for a range of IoT-related smart city and healthcare applications.

A LoRa Wide Area Network (LoRaWAN) can often traverse 20 km in rural regions and around 8 km in urban areas to guarantee the irrigation system has enough coverage.[7] The LoRa gadget may run for up to 10 years on a single charge because to its low power consumption. Long-term advantages include water conservation and cost savings on deployment and maintenance. As a result, this paper suggests a smart irrigation system based on LoRa technology.It is a great answer to the aforementioned issues. The proposed system enables LoRaWAN communication between irrigation applications and equipment. The major goal of the initiative is to make it feasible for cloud-based apps to operate the irrigation system. The gateway will receive the status data from the irrigation node, process it, and store it in the cloud. Application Programming Interfaces (APIs) for the cloud allow applications to communicate instructions to control the irrigation system. Another option for powering the solenoid valve on the irrigation node is a hydroelectric generator. The entire potential of energy may be exploited in this manner.

The usage of the LoRa 915 MHz band for agro-informatics is discussed in this paper[8]. Toxins that may enter agricultural soils from industrial and storm water sources can be measured and found using sensors with LoRa radios. Diseases affecting plant roots may be identified and categorised using buried sensors with cameras. A central LoRa concentrator that is located above ground may be utilised on a farm to broadcast samples of in-situ sensor data and camera pictures. The signal that is being carried by LoRa devices is diminished by both water and dirt, despite the fact that they may be immersed up to a specific depth. The signal-to-noise ratio (SNR) and received signal strength indicator (RSSI) are examined in this research for a variety of LoRa spreading factors, coding rates, and soil depths. Findings indicate For agro-informatics applications, the burying depth of a LoRa transceiver should not be more than 50 cm.

Using a chosen Spreading Factor and Bandwidth configuration, the performance and coverage results of the LoRa indoor and outdoor deployment are reported in this research[9]. A low-cost single channel gateway and a personal network application make up the LoRa network. All measurements were performed on the campus of the KDU University College in a genuine setting. As a whole, the LoRa network deployment environment does have an effect on the signal quality, particularly the high density of blockage level between the transmission channel, which has the most influence on the experiment's observed signal quality deterioration. The main elements affecting the performance of the LoRa network were spreading factor and bandwidth.

Longer communication ranges and increased noise immunity are made possible by lower bandwidth choices and higher spreading factors. This demonstrates the advantages of the LoRa network over competing wireless technologies. A single LoRa network deployment of a gateway or receiver may cover the whole structure. Since various LoRa parameter settings will have variable power consumption, which will be explored in the future, the LoRa parameter should be modified to the optimal setting for each site in the interim. Using off-grid power sources like batteries, the LoRa network's devices can run optimally for a few years.

When installing indoor sensor network systems, LoRa is used as an End Device node. The LoRa transceiver reliably transmits sensor data to the gateway with an average error rate of around 14.9 percent. A barrier preventing the gateway from connecting with LoRa, a lack of network connection, data flow in a server at risk of failure, or other transmission issues might be to blame. A few factors that may be taken into account to enhance system performance are the amount of data string bits, the channel frequency, and the interval time of data transmission. These settings may be altered depending on the characteristics of the parameters to be tracked. [10].

Due to the LoRa network's extensive coverage and low power requirements, a large range of LoRa-based applications in the IoT space have been developed. The design and implementation of a LoRa network, including hardware and software, have been suggested in this article in order to provide a versatile and comprehensive solution for building a private LoRa network. You may access the open source project there as well, according to GitHub. According to the field trials, our hardware's maximum gearbox range in cities is about 7.5 km. We also demonstrate how the upgraded LoRa architecture can support over 10,000 LoRa Nodes while preserving a suitable CPU resource distribution. This open LoRa network is anticipated to soon be in a position to provide the flexibility and viability necessary for both industry and academics to implement their cutting-edge LPWA applications. [11]

The installation and effectiveness of LoRa are the topics of this survey[12]. It is an essential component of networking in many IoT applications. The research's primary focus is the comparison and study of LoRa-based IoT communication patterns. LoRa has several uses and will continue to be important in the IoT sector. LoRa WAN provides a variety of benefits over other LPWAN technologies, including a long battery life, great range, and cheap cost. The sluggish data rate of LoRa is one of its key drawbacks.

Chapter 3

Project design

This chapter provides a quick summary of the project, the problem statement, the system block diagram, the project's goal, an overview of the components employed, and some basic ideas.

3.1 Introduction

The Internet of Things (IoT) and wireless sensing technologies are both used extensively in the contemporary scientific context. The Wireless Sensing Network, or WSN, is a tool that may help advance technology even as it rapidly evolves and develops. Studying wireless sensor networks presents a number of challenges, one of the most critical being the effective use of energy. The Internet of Things (IoT) and LoRaWAN are two technologies that might be used to discover a solution to this problem. [1] An automated irrigation system that takes soil moisture and other variables that may be regulated into account being developed as part of the precision agriculture (PA) movement because of the importance of these factors.

3.2 Problem Statement

[8] One of the challenges that agriculture presents is the difficulties that comes with monitoring agricultural areas that are located at a great distance from the farmer's house. Temperature in the air and moisture levels in the soil are two factors that influence agricultural crops. Both of these criteria need to be kept under check in order to achieve maximum agricultural yield. Spread spectrum chirp technology was the foundation for the spread spectrum modulation method known as Lora, which was the first low-cost application of spread spectrum chirp. Lora is able to transmit data up to 7.5 km distant using a frequency of 433 MHz. For the purpose of this investigation, LoRA technology was used to transmit data on the soil moisture and air temperature from one equipment to another. Because communication using this method may be carried out at a frequency of 433 MHz, it has the advantage of not being dependent on cellular frequencies. By establishing a connection between LoRA and the ESP32 microcontroller, which is in turn connected to an access point for sending data online via the use of the Ceyene application, monitoring may take place over the internet. The setting for the test is produced by altering factors such as the temperature of the air and the depth to which the sensor was buried in the ground. According to the findings of the research, LoRA technology makes it

possible to monitor soil temperature and humidity at a cheap cost.

3.3 Block Diagram

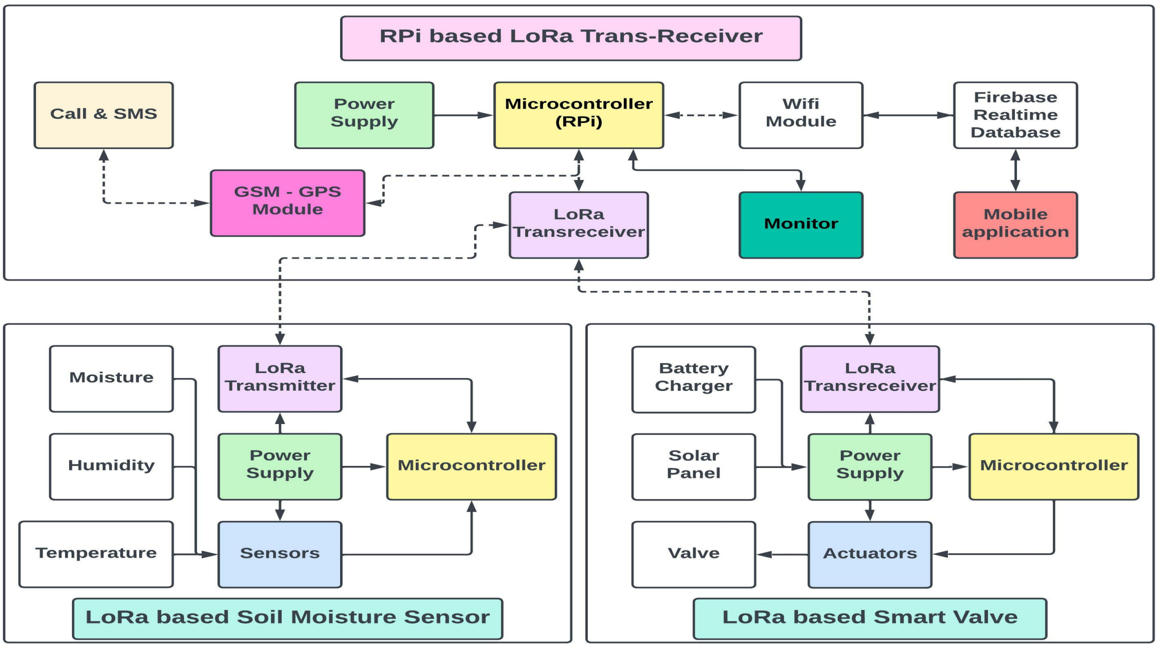


Figure 3.1: Block Diagram of the system

3.4 Objectives

The fundamental objective of this advanced irrigation system is to meet the needs of farmers in light of the shrinking work force. As a direct consequence of this problem, farmers face a significant number of challenges. As a consequence of this, it is very difficult for a regular farmer to determine whether or not the climate and soil conditions are suitable for the growth of their crops. Because of the exceedingly poor management of water resources and the absence of scientific progress in agricultural practises. Our contribution is on the use of LoRa technology and the internet of things to smart irrigation systems.

Up to 120 different devices with LoRaWAN connection may be accessed via our network. It is a piece of hardware that is capable of supporting communication in full duplex mode. This proposed approach, which is referred to as "an automatic irrigation using LoRaWAN," makes it easier to comprehend the ideal conditions for watering in terms of the soil and the relative humidity. In order to collect information on the amounts of moisture and humidity present in the different soils, a sensor has been installed. The data that were detected are sent to the control station via LoRaWAN. Several distinct measurements of the soil moisture and values of the relative humidity are sent to the control station from a number of different sources.

3.5 Overview of components used

- **LoRa-based soil Sensor**

Smart Soil sensor based on LoRa technology. It will detect the moisture, temperature and humidity of the soil and send those values in a string to the receiver. It is low power, highly efficient module which can be used in Smart agriculture (The communication range is up to 10km wirelessly)
Both the irrigation industry and plant gardens depend heavily on the soil's moisture. In the same way that nutrients in the soil provide plants sustenance for development. In order to adjust the plants' temperature, water must be provided to them. Utilising a process similar to transpiration, water may be used to modify a plant's temperature. Additionally, plant root systems grow more effectively in damp soil. Extreme soil wetness might result in anaerobic conditions that can promote the development of the plant and soil pathogens.

Figure 3.2: LoRa based soil moisture Sensor

Working Principle
The Atmega328P-based Lora-based Soil Moisture Sensor measures soil humidity using a capacitor-humility measuring method after collecting local air temperature and humidity using the sensor HX3004 first. It is appropriate for applications like smart farms, irrigation, agriculture, etc. since it can send data about the local environment to a gateway or other devices using Lora communication.

Square wave generation occurs on MCU.Additionally, deleting the 555 IC will result in a decrease in power consumption, which lengthens battery life. Lora When Lora is asleep, Soil Moisture closes the PWM outputs and ADC (this is significant since ADC influences some of the power usage). The microcontroller then enters sleep mode. Get up at the internal time and use AHT10 to determine the relative humidity and air temperature. To measure the soil moisture and battery voltage, enable the PWM outputs and ADC. then use Lora to send them out. Continue to repeat the job in progress.

The moisture level measurement and transmission to the LoRa receiver use the most energy. In low power mode for the majority of the time. The Macro SLEEPCYCLE determines the default sleep time. Sleep time is equal to (450+1)*8s=3608s, or about 60 minutes, when SLEEPCYCLE is specified as 450. Next, broadcast the info for around two seconds.

```
//Set sleep time, when value is 1 almost sleep (1+1)*8=16s,
when value is 450, almost 1 hour.
#define SLEEP_CYCLE 450
```

Figure 3.3: Sleep time settings

According to our tests, the low power consumption when sleeping is 7.1uA and the average power consumption while working is 9.88mA. It can theoretically operate for more than 77821 hours (more than 3 years) on two 1000mAh AAA batteries. It should be noted, nevertheless, that the ultimate lifetime is dependent on the battery and PCB's lifespans. Additionally, you may modify the sleep cycle (the SLEEPCYCLE variable in the code) to suit your needs.

Features

- Wireless Lora Transceiver
- Soil Moisture Measurement based on capacitive Testing
- Unique ID
- Low power: 7.1uA when sleeping. 2 years working life with 2xAAA battery
- Onboard HX3004 sensor to monitor air temperature and air humidity
- Onboard Battery Voltage Measurement
- Full Open Source- all hardware and software open at GitHub
- Compatible with Arduino
- Supply power voltage: 2.0V 3.3V
- 3D printing case

- **Smart Valve**

LoRa-based Smart Valve(Electric tap), which is connected through the water source to the drip irrigation system. It is operated according to the moisture readings of the soil received by him. It is a Lithium-ion battery operated with a micro-USB charging port in addition to Solar Panel to charge the battery.

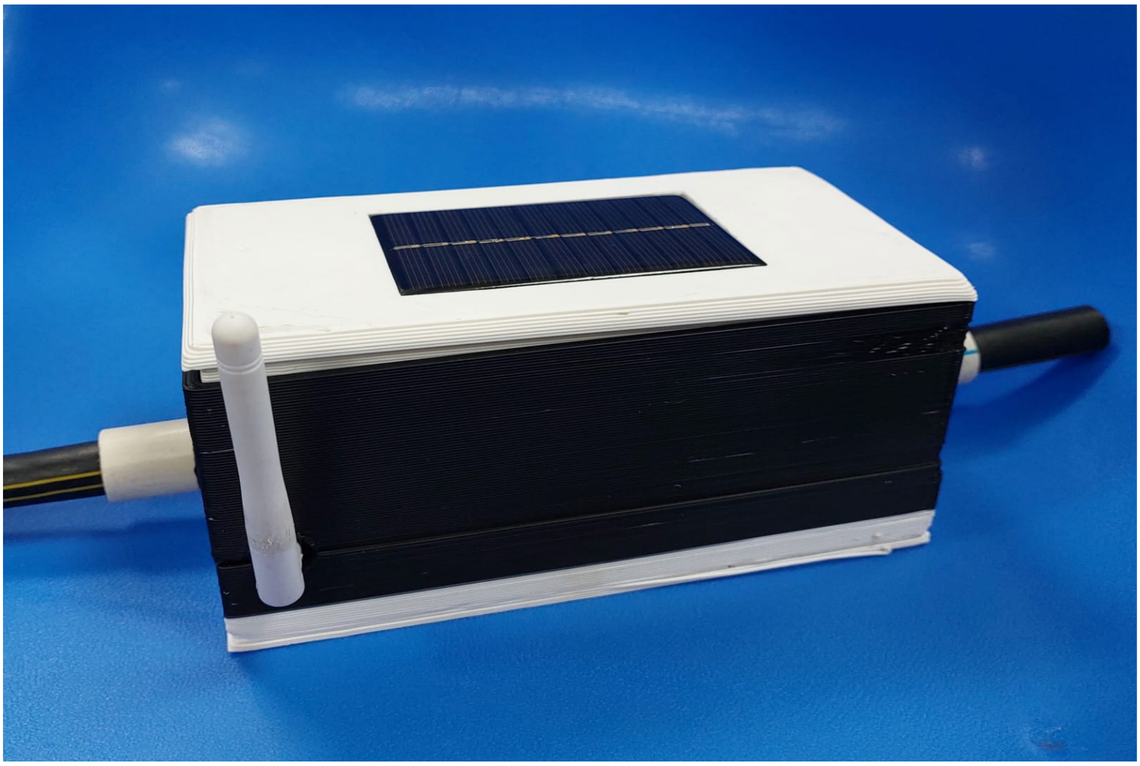


Figure 3.4: Smart valve electric tap

According to the World Bank, agriculture uses around 70 percent of all water withdrawals worldwide, and the UN's Food and Agriculture Organisation (FAO) estimates that 60 percent of that water is lost owing to ineffective application. Given the growing human population and the effects of climate change, water is becoming more and more important. One method I've discovered combines an embedded system with a drip irrigation system.

Smart Valve is basically an electric tap for the supply of water to the drip irrigation system. It will turn ON/OFF depending on the moisture of the soil or data received by him by the farmer. It will help in saving water and time for the farmer. He doesn't have to always look around for the dryness of the soil and turned the valve manually.

The suggested approach makes advantage of the long-range, low-power wireless capabilities of LoRa Technology to allow the deployment of inexpensive sensors to transport data from the farm to the cloud where it can be processed to enhance operations. The sensor node on the farm (Smart Valve) and a trans-receiver in the farmer's home essentially communicate in two directions. It can wirelessly connect at a distance of approximately 10 km while using little power because to its long-range capabilities.

The suggested system is powered by two 2500 mAh Lithium Ion 18650 batteries, and the Atmega328P microcontroller chip employed here spends half of its time in deep sleep mode to save power. The module is equipped with a micro-USB connector that may be used to charge it using a 5V 2A converter. Additionally, it features a solar panel that is parallel-connected to the adaptor and will use sunlight to charge the batteries while they are out in the field. Therefore, manually charging the batteries is not a concern.

3.6 Hardware components

- **RFM98W- sx1278 chip**

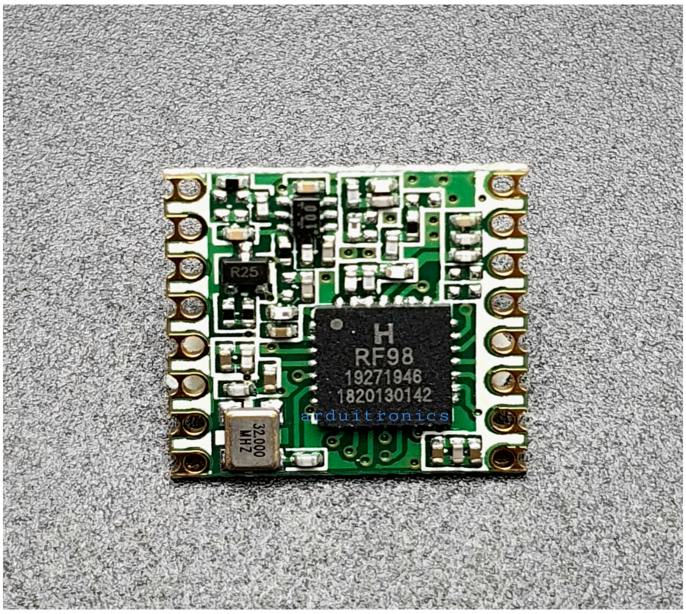


Figure 3.5: RFM98W- sx1278 module

The RFM98W transceivers feature a cutting-edge LoRaTM long-range modem, designed to provide reliable and long-distance spread spectrum communication while consuming minimal power. This exclusive LoRaTM modulation technology, combined with cost-effective components such as a low-cost crystal, allows the RFM96W module to achieve an exceptional sensitivity of over -148dBm.

The integration of a powerful +20 dBm power amplifier, along with its high sensitivity, gives the RFM98W transceivers an industry-leading link budget. This means that they can maintain a strong and reliable signal even over extended distances. By optimizing the trade-off between range, interference immunity, and energy consumption, LoRaTM technology offers significant advantages in terms of blocking, selectivity, and overall performance compared to other modulation systems.

In addition to their remarkable long-range capabilities, these transceivers also provide high-performance modes, including (G)FSK, suitable for IEEE 802.15.4g and WMBus systems. The RFM98W stands out from its competitors by delivering superior performance in phase noise, selectivity, receiver linearity, and IIP3 (third-order intercept point) while operating with lower current requirements.

With its efficient use of power, the RFM98W transceivers offer an optimal solution for applications that require both robustness and extended range. Whether it's in IoT deployments, smart agriculture, remote monitoring systems, or other similar scenarios, these transceivers can provide reliable long-distance communication with minimal power consumption.

To summarize, the RFM98W transceivers with their advanced LoRaTM long-range modem bring forth a remarkable combination of extended range, low power consumption, and robust interference protection. Their high sensitivity and integrated power amplifier ensure an industry-leading link budget, while LoRaTM technology addresses the traditional design trade-offs associated with long-range communication. Furthermore, these transceivers offer high-performance modes suitable for specific communication standards, making them a versatile and efficient choice for various applications that demand reliable, long-distance communication.

It has various features:

- LoRaTM Modem.
- 168 dB maximum link budget.
- +20 dBm - 100 mW constant RF output vs. V supply.
- +14 dBm high efficiency PA.
- Programmable bit rate up to 300 kbps.
- High sensitivity: down to -148 dBm.
- Low RX current of 10.3 mA, 200 nA register retention.
- Fully integrated synthesizer with a resolution of 61 Hz.
- FSK, GFSK, MSK, GMSK, LoRaTM and OOK modulation.

- **ATmega328p**

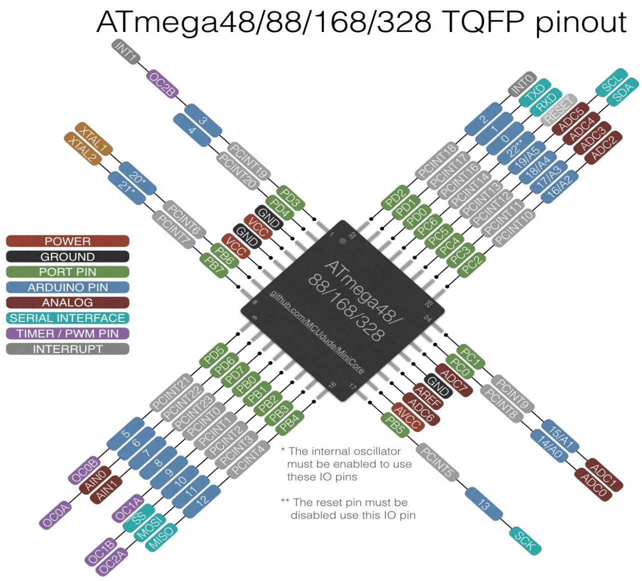


Figure 3.6: ATmega328p pin diagram

The ATmega328 microcontroller, part of Atmel's megaAVR series, stands out as a powerful single-chip solution for embedded systems. Originally developed by Atmel and later acquired by Microchip Technology in 2016, the ATmega328 incorporates advanced features and a high-performance 8-bit RISC CPU core with a modified Harvard architecture.

One notable aspect of the ATmega328 is its set of 32 general-purpose working registers. These registers provide a versatile workspace for executing instructions and storing data during runtime. With a broad range of general-purpose registers available, the microcontroller enables efficient data manipulation and processing, contributing to enhanced overall performance.

Among its capabilities, the ATmega328 boasts three flexible timer/counters that support compare modes. These timer/counters offer various functionalities, such as generating precise timing intervals, measuring external events, and facilitating pulse width modulation (PWM) operations. This flexibility allows for accurate timing control, event monitoring, and the implementation of various time-based operations.

To enhance its responsiveness, the ATmega328 incorporates an internal and external interrupt system. This feature enables the microcontroller to quickly respond to external events or triggers by interrupting the normal program execution. With configurable interrupt priorities, developers can efficiently handle critical events and ensure timely processing within the system.

Furthermore, the ATmega328 includes a serial programmable USART (Universal Synchronous/Asynchronous Receiver/Transmitter). This USART provides a flexible and straightforward interface for serial communication, allowing seamless data exchange between the microcontroller and other devices or communication networks. The USART supports both synchronous and asynchronous communication modes, further enhancing its versatility.

In addition to the USART, the ATmega328 offers a byte-oriented 2-wire serial interface, commonly known as I2C. This interface facilitates simple and efficient communication with compatible devices, enabling the microcontroller to interact with a wide range of sensors, displays, and other peripheral devices that support the I2C protocol.

The microcontroller also incorporates an SPI (Serial Peripheral Interface) serial port, which enables high-speed communication with external devices that follow the SPI protocol. This interface is particularly useful for applications that require fast data transfer rates, such as memory devices, displays, and sensor arrays.

To support analog measurements, the ATmega328 integrates a 6-channel 10-bit analog-to-digital converter (ADC). In certain package variants, such as TQFP and QFN/MLF, the ADC supports up to 8 channels. This ADC allows the microcontroller to convert analog signals, such as sensor readings, into digital values for further processing and analysis within the system.

In terms of reliability, the ATmega328 includes a programmable watchdog timer. This timer acts as a safety mechanism by monitoring the system's operation and triggering a system reset if any anomalies or malfunctions occur. By utilizing the watchdog timer, developers can ensure the stability and robustness of their applications, guarding against potential issues that could lead to system failures.

Operating within a voltage range of 1.8 to 5.5 volts, the ATmega328 exhibits efficient power consumption characteristics. Its low-power design and optimized architecture allow it to deliver nearly 1 million instructions per second (MIPS) per megahertz (MHz) of clock speed, striking a balance between performance and energy efficiency.

The ATmega328 microcontroller offers a comprehensive set of features and robust performance for a wide range of embedded applications. With its advanced architecture, flexible peripherals, and efficient power management, the ATmega328 empowers developers to create innovative and reliable solutions while optimizing power consumption and system performance

The ATmega328 is often used in a variety of applications and autonomous systems that call for a simple, affordable micro-controller. This chip may be found most commonly in the popular Arduino programming platform's Arduino Uno, Arduino Pro Mini, and Arduino Nano iterations.

Both designs for smart valves and soil moisture sensors have utilised this chip.

- **SIM800L GSM Module**

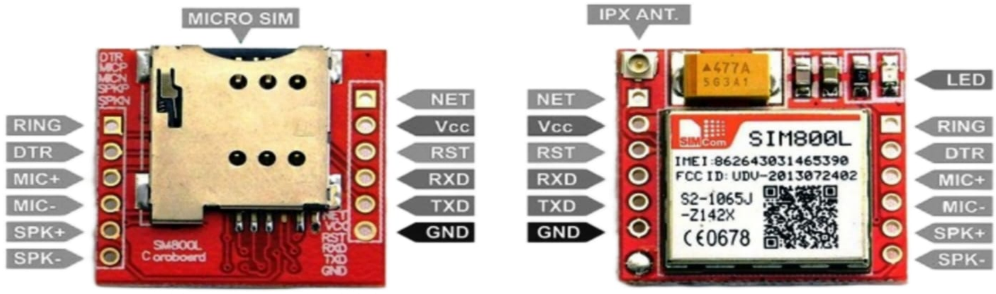


Figure 3.7: SIM800L pin diagram

The integration of a microcontroller with the SIM800L GSM/GPRS module from Simcom offers a versatile solution for enabling cellular communication in various projects, including the LoRa-based Smart Irrigation System using IoT. The microcontroller acts as the central processing unit of the system, facilitating control and data processing tasks. On the other hand, the SIM800L module serves as a compact and cost-effective cellular modem, providing access to both GSM and GPRS capabilities.

By utilizing the SIM800L module, the microcontroller can establish a connection with the mobile network and access the internet. This connection enables the system to send and receive data packets through GPRS, TCP, or IP protocols, allowing seamless communication over long distances. Moreover, the SIM800L module's quad-band GSM/GPRS support ensures compatibility with various mobile networks globally, making it suitable for projects requiring worldwide coverage.

One of the key advantages of the SIM800L module is its ability to send and receive SMS messages. This feature can be leveraged in the smart irrigation system to receive alerts or notifications regarding critical events, such as low water levels or equipment malfunctions. Additionally, the module enables the microcontroller to make and receive phone calls, providing a convenient means of remotely monitoring and controlling the irrigation system.

In summary, the integration of the SIM800L GSM/GPRS module with a microcontroller offers a reliable and compact solution for enabling cellular connectivity, internet access, SMS messaging, and phone call functionality in the LoRa-based Smart Irrigation System using IoT. This combination not only enhances the system's capabilities but also provides compatibility with global mobile networks, making it suitable for a wide range of IoT applications requiring long-distance communication and remote connectivity

- **L9110S Motor Control Driver**

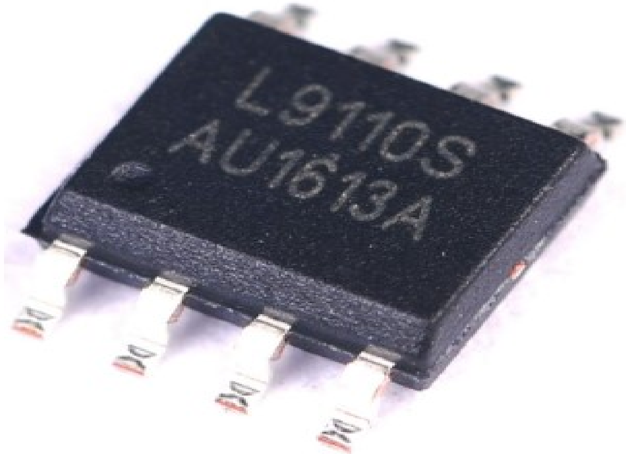


Figure 3.8: L9110S Motor Control driver

The L9110 is a highly efficient and compact integrated circuit (IC) specifically designed for controlling and driving motors. It integrates a two-channel push-pull power amplifier with discrete circuits into a single monolithic chip, resulting in reduced costs and improved overall reliability of motor control systems.

One of the key advantages of the L9110 is its compatibility with TTL/CMOS logic levels, providing seamless integration with a wide range of control systems. The two input terminals are designed to withstand different signal levels and exhibit excellent resistance, ensuring reliable and accurate signal transmission.

The chip also features two output terminals that directly control the movement of the motor in both forward and reverse directions. It boasts a high current driving capability, with each channel capable of delivering a continuous current of 750 800mA, and peak current capabilities of up to 1.5 2.0A. This robust current handling capacity makes the L9110 suitable for driving various types of motors and handling different load requirements.

Another notable feature of the L9110 is its low output saturation voltage, which minimizes power losses and ensures efficient power transfer to the motor. Additionally, it incorporates a built-in clamp diode that protects against current spikes generated by inductive loads, making it safe and reliable for driving relays, DC motors, stepper motors, and switch power tubes.

The versatility of the L9110 extends to its wide range of applications. It is commonly used in toy car motor drives, providing precise control and smooth operation for enhanced playability. The chip also finds application in stepper motor drives, enabling accurate positioning and precise rotational control in various systems. Furthermore, the L9110 is utilized in switching power tube circuits, contributing to efficient power management and ensuring reliable performance.

The compact size and cost-effectiveness of the L9110 make it a popular choice for motor control applications across different industries. Its integrated design, combined with its ability to deliver high currents and provide reliable protection mechanisms, makes it an ideal solution for various motor control needs.
Some of its features are:

- Voltage Supply range 2.5 Volts to 12 volts

- Per channel 800 mA continuous current output capability
- Operating temperature: 0 â -80 â

- **LoRa Antenna 433MHz**

Figure 3.9: LoRa antenna 433 MHz

This is a gain antenna for a 433 MHz serial wireless transmitter. The set of components required to modify the tile so that an external WiFi antenna may be connected is the object of the auction. Your Raspberry Pi Zero W's WiFi range may be extended with this upgrade. All parts are brand-new and fully working. Additionally, they are ideal for use in custom 3G/4G/LTE routers built using MikroTik and Sierra Wireless cards.
Its features are:

- 433 MHz center frequency
- 3.6 db peak gain
- 20C to +85C operating temperature range
- ¡ 2.0 typical at center VSWR

- **Magnetically latching solenoid valve**

One of the key advantages of this valve is its compatibility with battery-operated sensor taps. These taps are highly convenient to install and require lower maintenance compared to conventional taps. They eliminate the need for plumbing or electrical wiring at the installation location, making them ideal for both new installations and retrofitting projects where traditional taps need to be replaced.
Unlike electrical water valves that rely on a continuous power source, this valve is designed to operate efficiently using low-cost, low-powered batteries such as 6V lithium

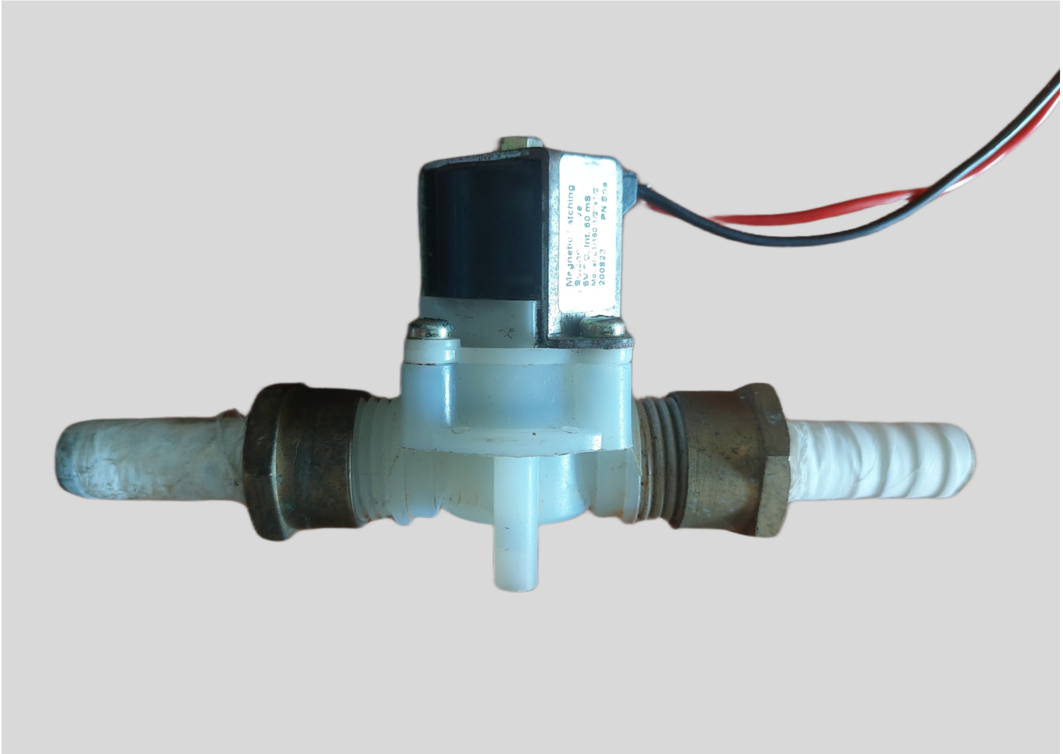


Figure 3.10: Magnetically Latching Solenoid Valve

camera batteries or alkaline batteries. This enables the battery-operated sensor taps to function reliably without the need for a continuous power supply
Some of its features are:

- Lower operating time up to 60ms
- Wider operating voltage range from 3.5 V DC to 12 V DC
- Plastic body for longer, trouble-free operations
- Higher mechanical life of more than 450 000 cycles

How does it work?
Magnets and electrical current are used by magnetically latching solenoid valves to carry out functions while using very little electrical power. Depending on the polarity of the magnet and the direction of the current flow, the valve latches or unlatches when electrical current is introduced to the coil. If a valve is in the delatched position and current polarity is reversed, it latches, and vice versa.

- **TC2117-3.3VDBTR**

A fixed high-accuracy CMOS low dropout positive regulator for battery-powered devices is the TC2117-3.3VDBTR. Because to the CMOS design of the TC2117, no ground current is wasted, thus prolonging battery life. At no load, the total supply current is usually 80 A, 20 to 60 times less than in bipolar regulators. Ultra low noise, extremely low dropout voltage (usually 600mV at full load), and quick reaction to step changes in load are among of the TC2117's primary characteristics. Both over-temperature and over-current safety are included into the TC2117. The TC2117 has a maximum output current of 800mA and is stable with a 1F output capacitor.
It has very low dropout voltage and high output voltage accuracy.
Some of its specifications are:

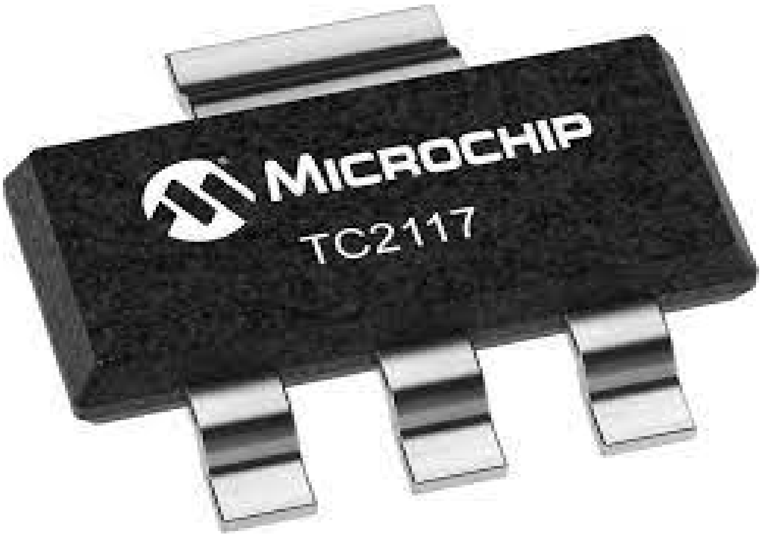


Figure 3.11: Fixed LDO Voltage Regulator

- 2.7 to 6 volts output voltage
- Dropout voltage of 450mV
- 800 mA maximum output current
- 125 degree celcius maximum operating temperature
-

- **LGDAS31865 Battery**

Figure 3.12: LGDAS31865 Battery

LG Chem created the LGDAS31865 lithium-ion battery. It is intended for high-performance power storage applications like EVs and ESS.

The LGDAS31865 battery's high energy density makes it efficient and lightweight. It's ideal for space- and weight-sensitive applications.

The LGDAS31865 battery is durable, with a long cycle life. This assures long-term performance.

The LGDAS31865 battery provides robust, steady power due to its high power output. Acceleration and power supply applications demand this.

The LGDAS31865 battery has enhanced protection against overcharging, overdischarging, and short circuits for safety. These features prevent accidents and damage.

LG Chem's LGDAS31865 lithium-ion battery is stable and efficient, meeting industry demands. High-performance power storage applications benefit from its small size, extended cycle life, high power output, and safety features.
Specifications:

- It has It has 2200 mAH rated capacity
- 3.60 V nominal voltage
- Charging :4.20V Maximum, 1075mA Standard, 2150mA Maximum
- Discharging : 3.00V Cutoff, 430mA Standard, 3225mA Maximum

- **TP4056 1A Li-Ion Lithium Battery charging Module with Current Protection**

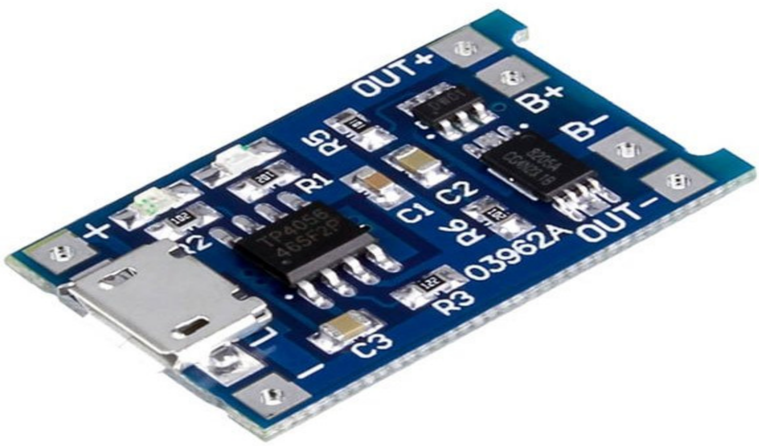


Figure 3.13: Battery Charging Module

This compact module, the TP4056 1A Li-Ion Battery Charging Board Micro USB with Current safety, is ideal for charging single-cell lithium-ion (Li-Ion) batteries with a 3.7V 1 Ah or greater but no built-in safety circuit, such as 16550s. This module will provide a 1A charge current and then shut off once the charge is complete based on the TP4056 charger IC and DW01 battery protection IC.

Additionally, the protection IC will turn off the load when the battery voltage falls below 2.4V to prevent the cell from operating at too low of a voltage. It also protects against over-voltage and reverse polarity connection (it will typically destroy itself rather than the battery), so please double-check your connections the first time.
Features :

- Led indicator: red is charging Green is fully charged.
- Current Protection: Yes
- Inversed polarity: NO.
- Use mature charging chip TP4056 for simple peripheral circuits, good protection performance, and high charging accuracy.

- **Uni4 0.6 Watt Polycrystalline Mini Epoxy Solar Panel**

Figure 3.14: Polycrystalline Mini Epoxy Solar Panel

3.7 Softwares used

- **Arduino IDE** Arduino Integrated Development Environment, generally known as the Arduino Software (IDE), is also available. It includes a text editor for writing code, a message box, a text terminal, a toolbar with buttons for frequently used activities, and a variety of menus. It connects to the Arduino hardware to upload programming and interact with them.

  The Arduino IDE is used to build computer programmes known as sketches. These illustrations are produced in a text editor, then saved as files with the.ino extension. Text replacement and text searching options are available in the editor. The message area reveals issues and offers feedback when saving and exporting. The terminal displays text produced by the Arduino Software (IDE), together with additional data including complete error messages. In the bottom right corner of the window, you can see the configured board and serial port. Using the toolbar buttons, you may create, open, and save drawings, verify and submit scripts, see the serial monitor, and more.

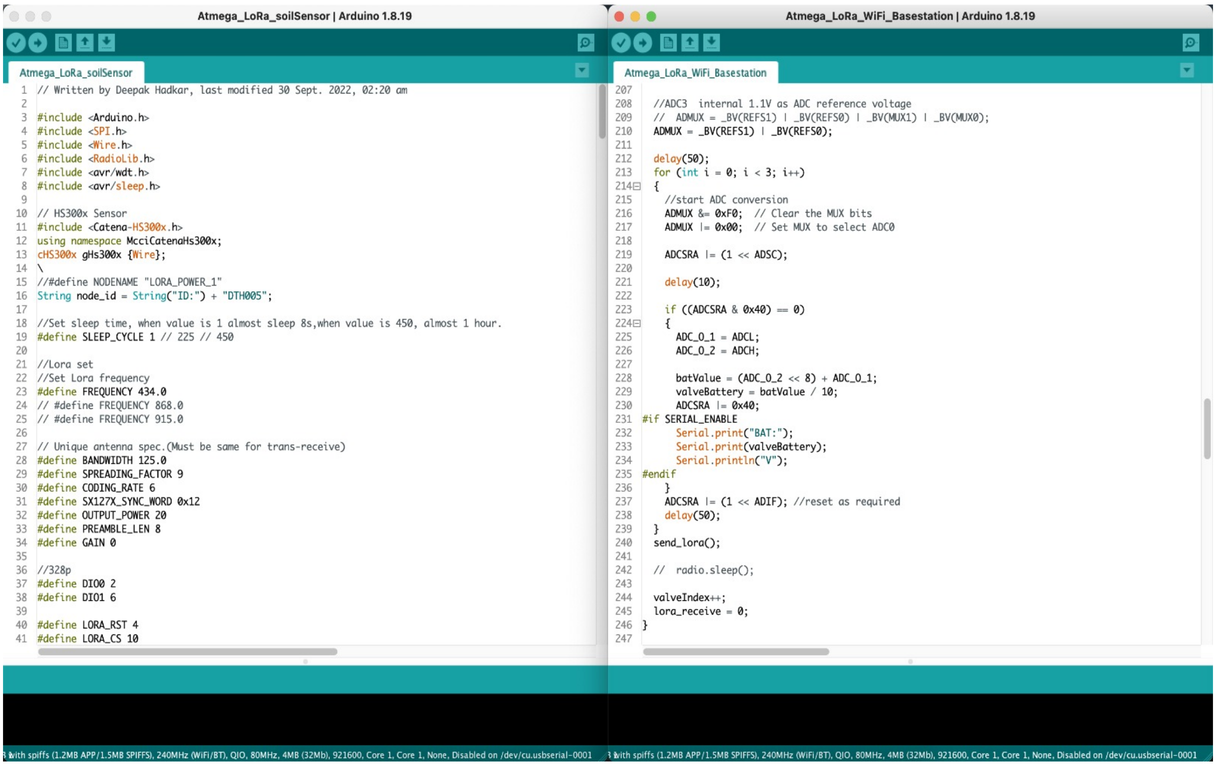


Figure 3.15: Arduino IDE window

- **Visual Studio Code**

Visual Studio code was used to write the website's HTML, CSS, and JavaScript scripts as well as to create the I2C protocol. The condensed code editor Visual Studio Code supports task execution, debugging, and version management. It aims to provide developers with the bare minimum of tools necessary for a quick cycle of code-build-debugging and leaves more complex processes to IDEs with more functionality, like Visual Studio IDE.

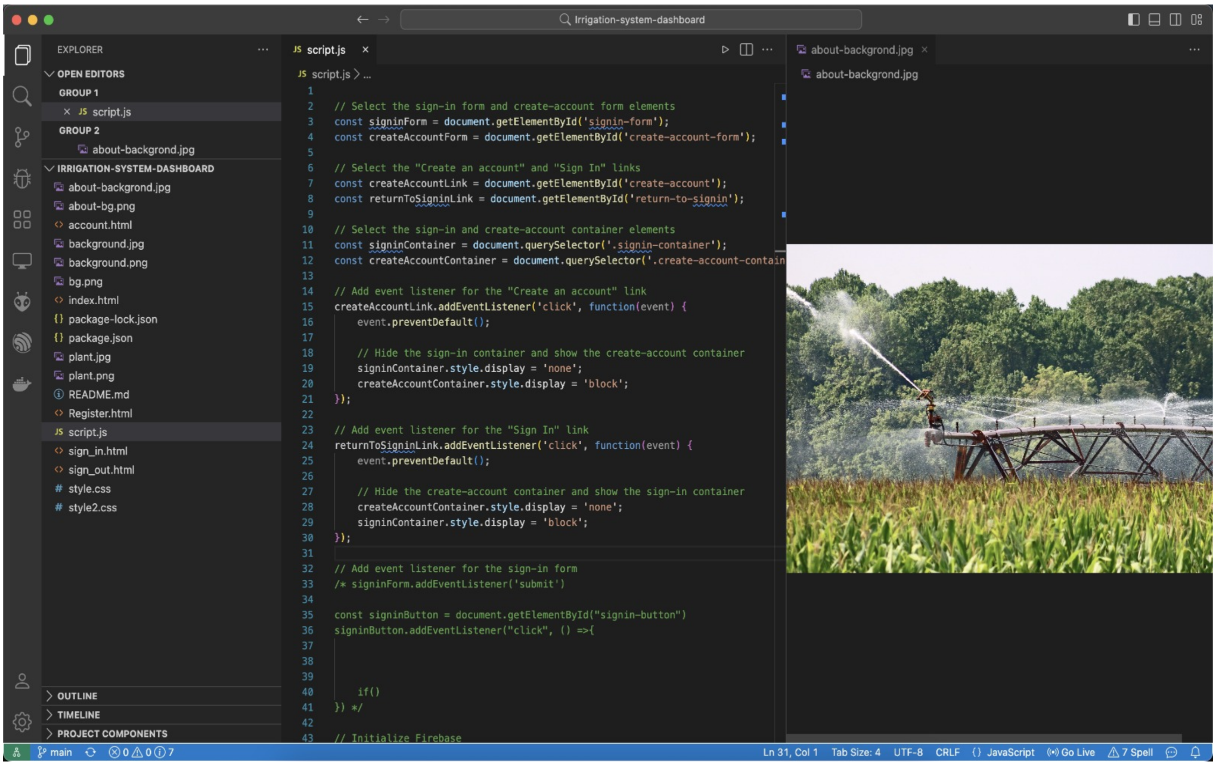


Figure 3.16: VS code window

Chapter 4

Implementation - Designing compact and individual models

The project's implementation and experimentation details are included in this chapter, along with an explanation of the project's hardware implementation and the nature of the components employed.

4.1 Issues Faced

Our team recognized the importance of developing a durable and cost-effective solution for farmers, while also prioritizing the compactness of the final product. Our primary objective was to create a compact transmitter module that could withstand the harsh weather conditions typically encountered on farms and provide accurate data.

To achieve this, extensive research and development efforts were undertaken. We explored innovative approaches and engineering techniques to significantly reduce the size of the transmitter, receiver, and sensor modules without compromising their data accuracy and reliability. We carefully considered the trade-off between size reduction and performance, aiming to strike the optimal balance.

The selection of materials played a crucial role in ensuring the durability of the modules. We sought out weather-resistant materials and implemented robust sealing mechanisms to protect the internal electronics from moisture, dust, and other potential environmental challenges. By utilizing high-quality components and adhering to rigorous testing procedures, we aimed to guarantee the modules' ability to withstand the demanding conditions of farm environments.

In parallel, our team focused on optimizing the circuitry design and leveraging advanced miniaturization techniques. We carefully analyzed and streamlined the architecture of the modules, identifying opportunities for component consolidation and space optimization. Through the use of efficient microcontrollers and advanced manufacturing processes, we achieved significant size reduction while preserving the modules' data collection capabilities.

The compact design we developed not only facilitates easy installation on farms but also provides flexibility in placement, considering the limited space available in agricultural settings. Farmers can seamlessly integrate the transmitter module into their existing infrastructure without sacrificing the accuracy and reliability of the data collected.

By successfully meeting our goal of creating a compact and efficient solution, we aimed to empower farmers with a practical tool that enhances their agricultural practices. The compactness of our design offers benefits such as improved portability, space efficiency, and simplified installation. Ultimately, our solution provides farmers with a reliable and cost-effective means of collecting accurate data for informed decision-making and efficient farm management.

4.2 Soil moisture sensor

A significant challenge in the current market for soil moisture sensors lies in their susceptibility to corrosion and limited durability. To address this concern and develop a sensor that excels in longevity and practicality, we embarked on a quest for an innovative non-contact sensing method that would yield comparable results. Our aim was to ensure accurate soil moisture measurements while extending the sensor's lifespan.

After careful evaluation, we determined that a capacitive sensing approach offered the most promising solution. By leveraging capacitive technology, we could achieve reliable and corrosion-resistant measurements while minimizing physical contact with the soil. This approach also enabled us to explore additional parameters such as temperature and humidity, making the sensor a comprehensive solution for soil analysis.

Compactness was another crucial consideration during the sensor's design. We sought to optimize the sensor's physical footprint to save space and allow for convenient integration into various environments. By employing efficient design practices and leveraging the latest advancements in miniaturization, we were able to create a compact sensor without compromising its performance.

To ensure seamless data transmission and reception, we integrated a controller based on the Atmega328p microcontroller. This enabled real-time monitoring and data exchange while maintaining continuous functionality. By incorporating efficient communication protocols, we ensured that the sensor could transmit data reliably even while actively observing and analyzing the environmental conditions.

Energy efficiency was a paramount concern throughout the development process. We meticulously optimized power consumption to extend the sensor's battery life and enhance its overall efficiency. As part of this strategy, we made a deliberate decision to avoid the use of LEDs, focusing solely on essential functionality to minimize energy requirements.

To bring our vision to life, we utilized the capabilities of EasyEDA, a powerful electronic design automation tool. Through EasyEDA, we seamlessly merged all the components, circuits, and connections, resulting in a well-integrated and robust sensor system. As a tangible output of our design efforts, we created a detailed 3D model, allowing for a comprehensive visualization of the sensor's physical structure and layout.

In summary, our developed soil moisture sensor overcomes the limitations of traditional corrosion-prone sensors by utilizing capacitive sensing, which ensures longevity and reliable measurements. The sensor's compact design, integration with the Atmega328p controller, real-time data transmission, and energy-efficient operation collectively contribute to its effectiveness and practicality. By striving to innovate and optimize at every stage of the design process, we have successfully created a powerful and enduring sensor solution for soil moisture analysis

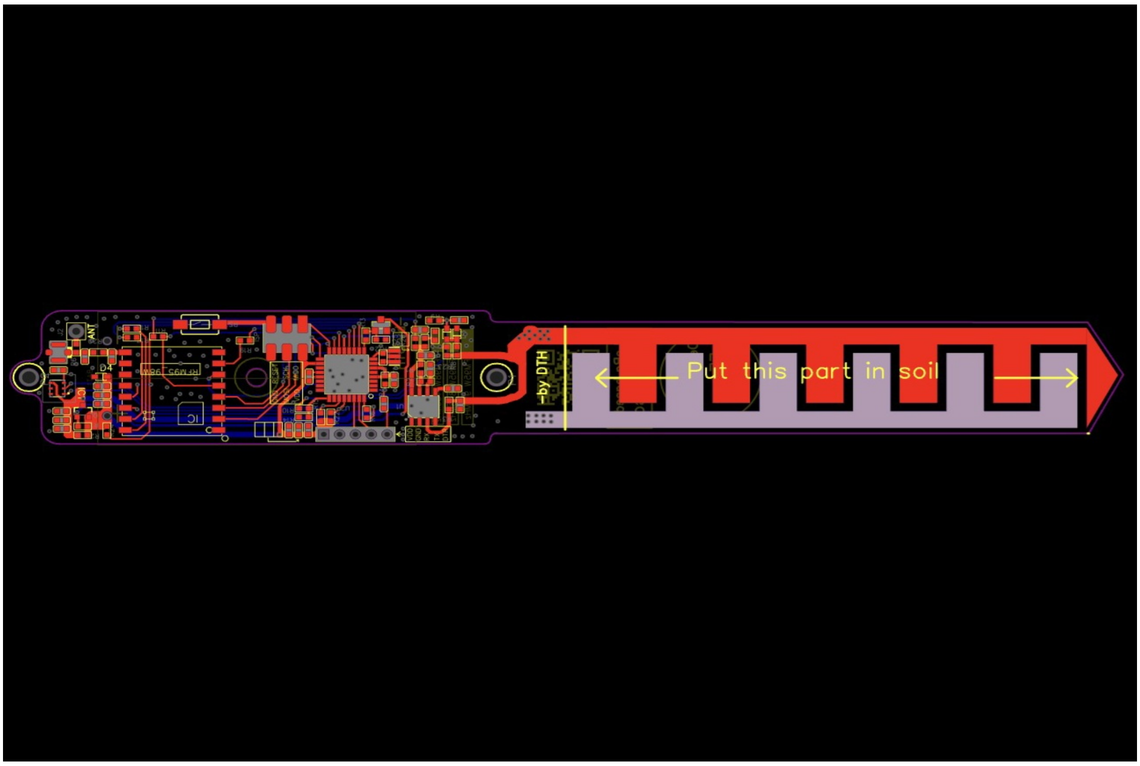


Figure 4.1: 3D PCB model of Moisture sensor

4.3 Smart valve

This innovative idea revolutionizes the agricultural landscape by introducing low-cost sensors capable of seamlessly transferring crucial farm data to the cloud. This data can then be thoroughly analyzed to optimize operational efficiencies and enhance agricultural practices. Leveraging the remarkable long-range and low-power wireless capabilities of LoRa Technology, this sensor solution offers a practical and cost-effective approach to farm monitoring and management.

At the heart of this system lies the Smart Valve, a sensor node strategically positioned within the farm. This Smart Valve interacts bidirectionally with a transceiver located in the farmer's house, establishing a reliable and efficient wireless connection. The exceptional long-range capabilities of the Smart Valve enable wireless communication over distances of up to 10 kilometers, minimizing the need for additional infrastructure while ensuring extensive coverage across the farm.

To power the Smart Valve, two Lithium Ion 18650 batteries are employed, combining for a total capacity of 2500 mAh. The Smart Valve's design optimizes energy consumption by utilizing the Atmega328P microcontroller chip, which is programmed to enter a power-saving deep sleep mode for 50 percent of the time. This intelligent power management strategy significantly extends the battery life, allowing for prolonged operation without frequent battery replacements.

To facilitate convenient charging, the Smart Valve is equipped with a micro-USB connection that can be used in conjunction with a 5V 2A converter. This setup enables easy and efficient charging whenever required. In addition, the Smart Valve incorporates a solar panel that operates in parallel with the charging adapter. Harnessing the abundant and renewable energy provided by sunlight, the solar panel charges the batteries while the Smart Valve is deployed in the field. This innovative integration of solar charging eliminates the need for manual battery charging, reduces maintenance efforts, and ensures uninterrupted operation even in remote farm locations.

By combining the power of reliable battery operation, optimized power management through deep sleep mode programming, and sustainable solar charging, the Smart Valve achieves an efficient, self-sustaining power system. This approach enhances the practicality and reliability of the sensor solution, providing continuous data collection and transmission without the limitations of traditional power sources.

In summary, this groundbreaking sensor solution, powered by LoRa Technology, offers a cost-effective and efficient means of transmitting essential farm data to the cloud. The Smart Valve's long-range capabilities, optimized power management, and integrated solar charging make it an invaluable asset in agricultural monitoring and management. By harnessing the power of renewable energy and advanced wireless technology, this solution contributes to improved agricultural practices, increased operational efficiencies, and sustainable farming practices

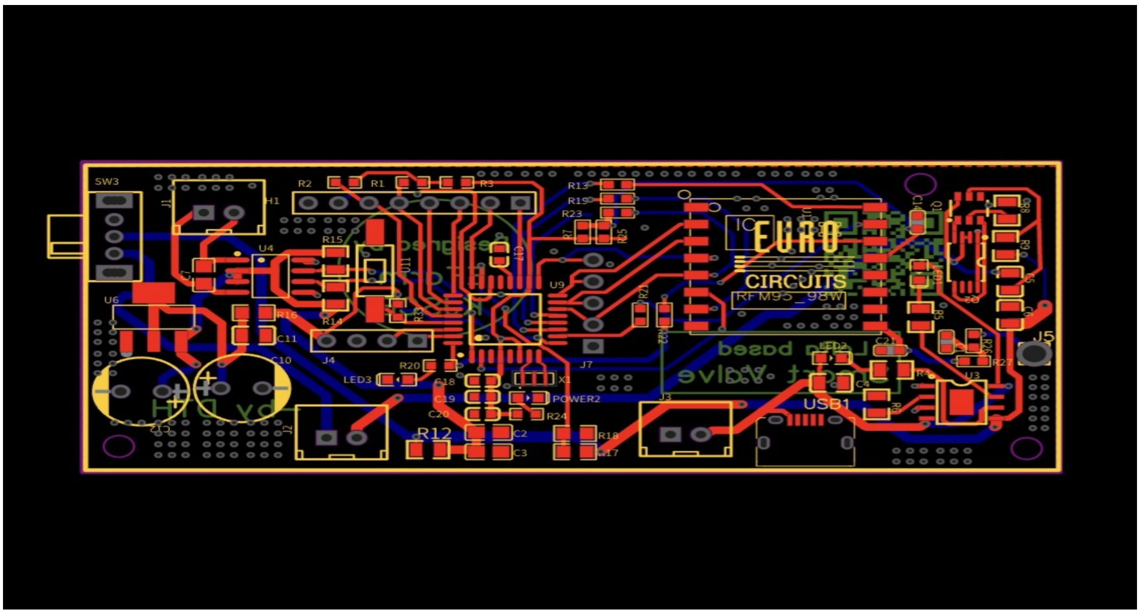


Figure 4.2: PCB model of smart valve

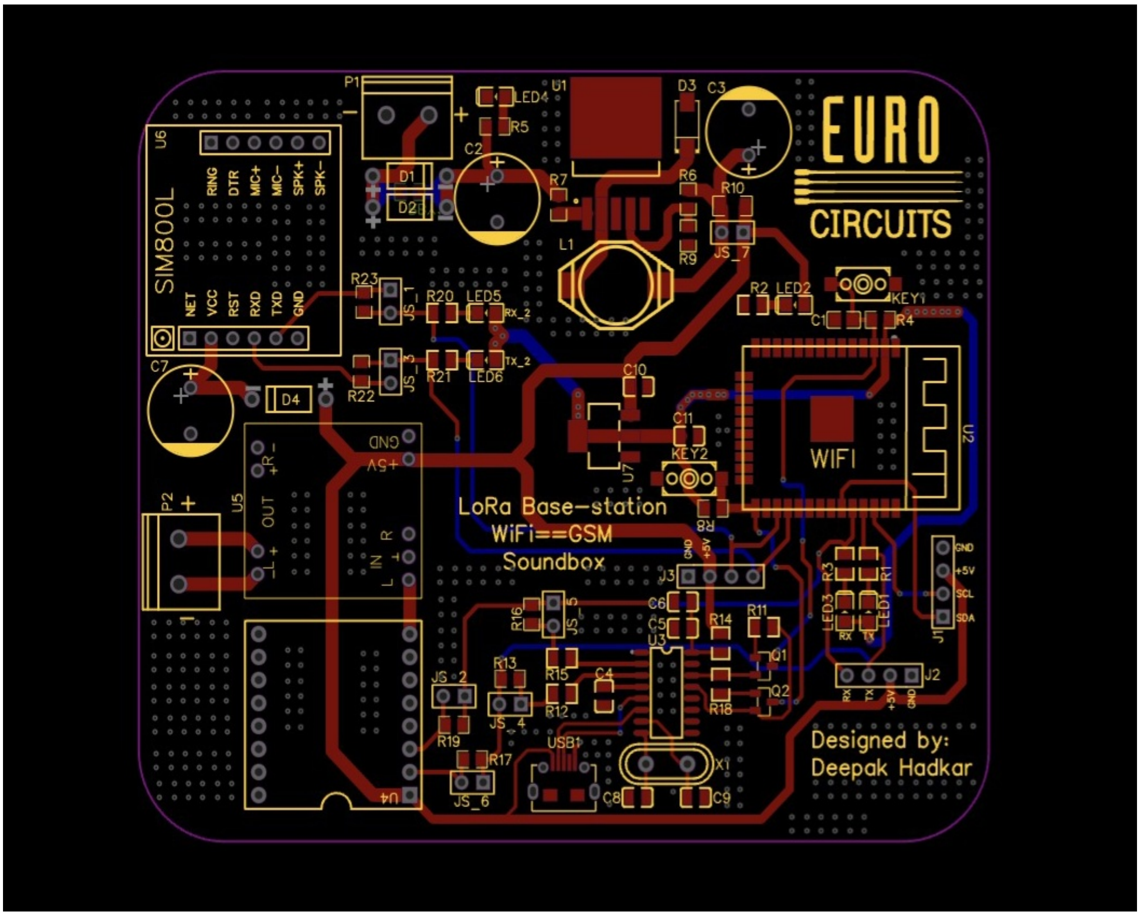


Figure 4.3: PCB model of Base station

4.4 Web application

Introducing SmartAgro, the all-in-one solution for smart and efficient agricultural management. Our innovative website offers a comprehensive suite of features designed to enhance every aspect of your farming experience. With SmartAgro, we aim to revolutionize the way you manage your agricultural endeavors by leveraging the power of technology, simplicity, and efficiency at your fingertips.

One of the key benefits of SmartAgro is its ability to provide real-time monitoring and analysis of your crops. Our intuitive interface allows you to effortlessly track the growth and progress of your plants, ensuring optimal conditions for maximum yield. By accessing crucial data on soil moisture, temperature, and humidity, you can make informed decisions and take proactive measures to protect your crops from potential risks and challenges. Whether it's adjusting irrigation schedules or implementing timely pest control measures, SmartAgro empowers you to stay one step ahead and optimize your agricultural practices.

But we don't stop there. SmartAgro goes beyond traditional farming platforms by offering additional features that add value to your farming operations. Our integrated e-commerce product links connect you to a wide range of agricultural products and technologies available in the market. This not only generates revenue opportunities for your business but also keeps you informed about the latest advancements in the industry. With just a few clicks, you can explore and access cutting-edge solutions to further enhance your farming practices.

Managing your farming activities becomes a breeze with the SmartAgro calendar system. You can easily schedule and organize important events such as watering schedules, fertilizer application, and pest control. This ensures that all essential tasks are performed on time, eliminating the risk of overlooking critical farming activities. As we continue to improve our platform, we are actively working on incorporating reminders and notifications to keep you updated and ensure nothing falls through the cracks.

At SmartAgro, we prioritize the security and privacy of your data. Our state-of-the-art encryption protocols and secure storage infrastructure guarantee the highest level of protection for your login credentials and sensitive information. With the peace of mind that comes from knowing your data is secure, you can access your SmartAgro account from any device, anytime, and continue managing your agricultural operations seamlessly.

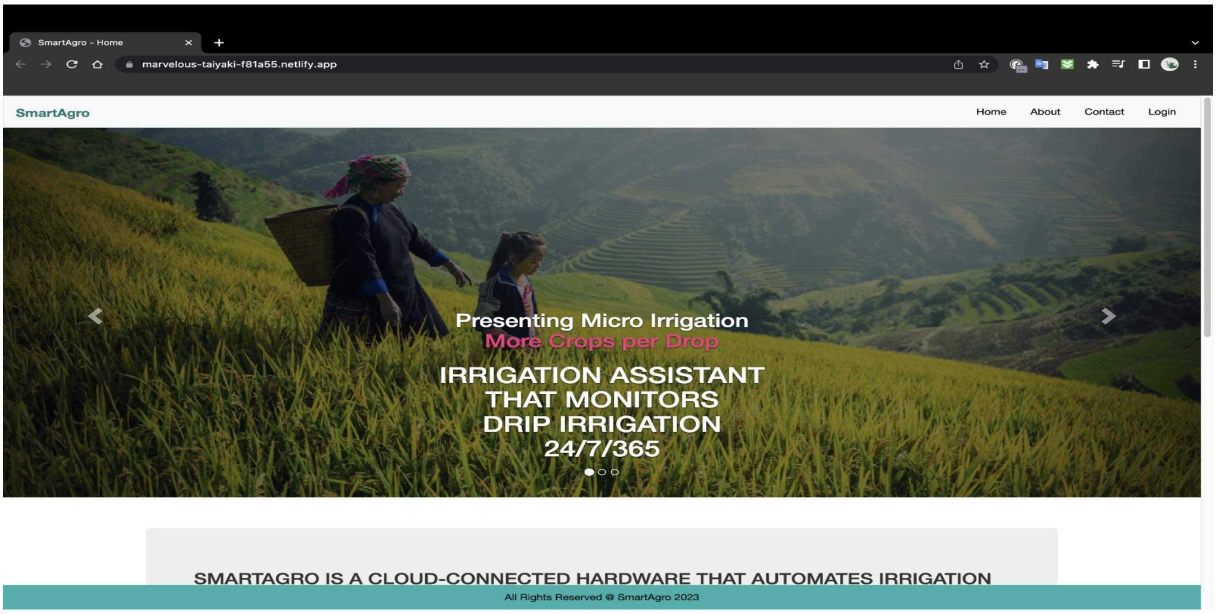


Figure 4.4: Display page of Web application

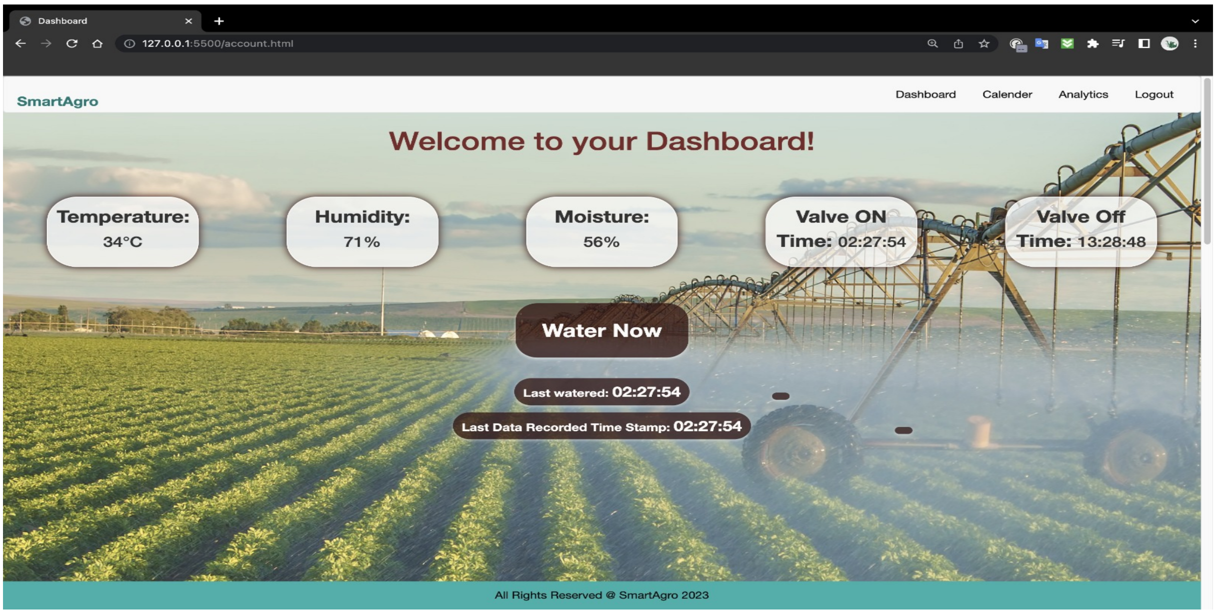


Figure 4.5: Dashboard of Web application

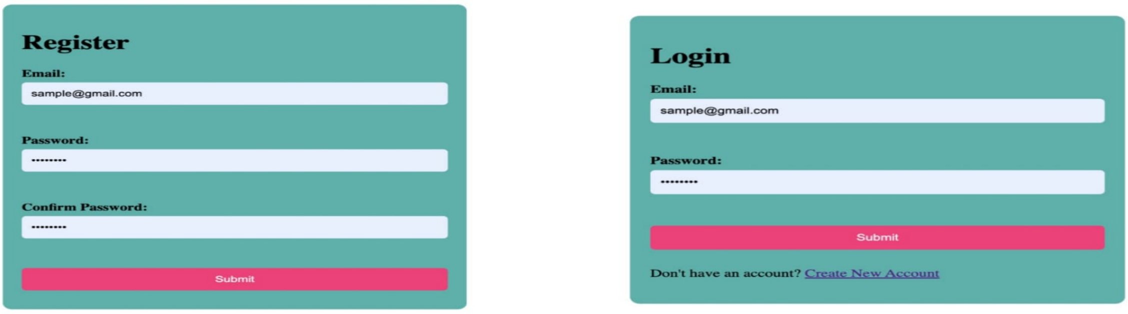


Figure 4.6: Login Registration page of Web application

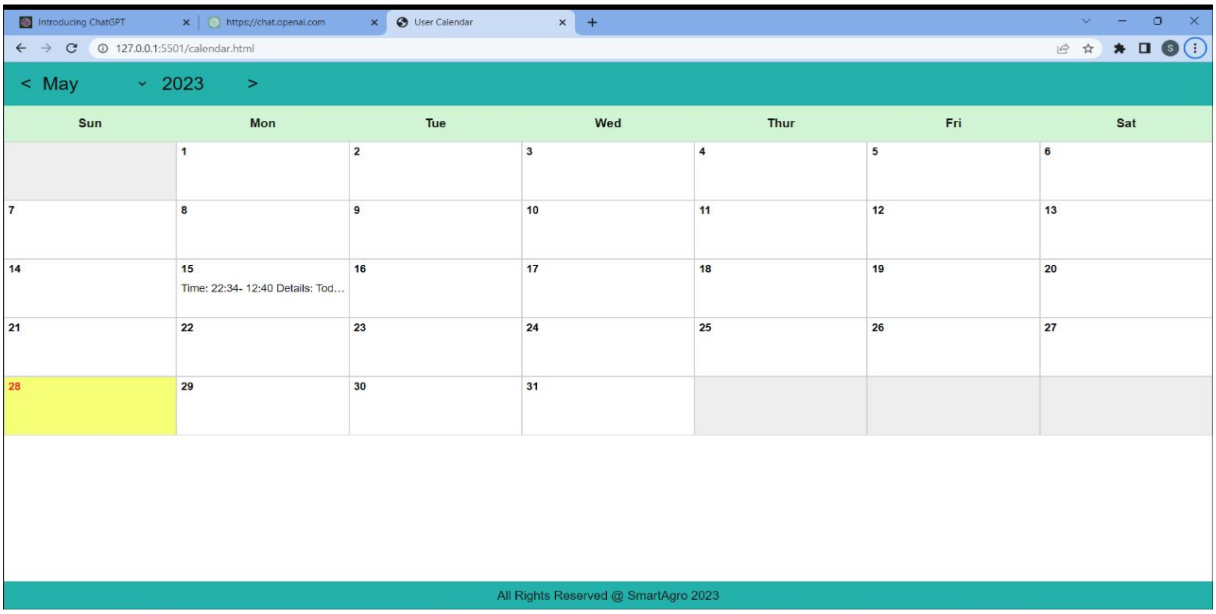


Figure 4.7: Calender

4.5 3D Printing

The groundbreaking technique known as "3D printing" enables the production of physical items with three dimensions, starting with computer blueprints. Objects are constructed one layer at a time using this method, with more material being added on top of each layer as it progresses towards completion. The term "additive manufacturing" may also be used to refer to this method.

The adaptability of 3D printing is seen as one of the technology's primary benefits. It is capable of producing a diverse variety of items, from simple prototypes to designs that are complicated and detailed in nature. The technique has found use in a variety of fields, including construction, healthcare, aerospace, architecture, and education, among others.

Printing three-dimensional objects has various advantages over more conventional production processes. Because costly tooling or moulds aren't required for manufacturing, the process may

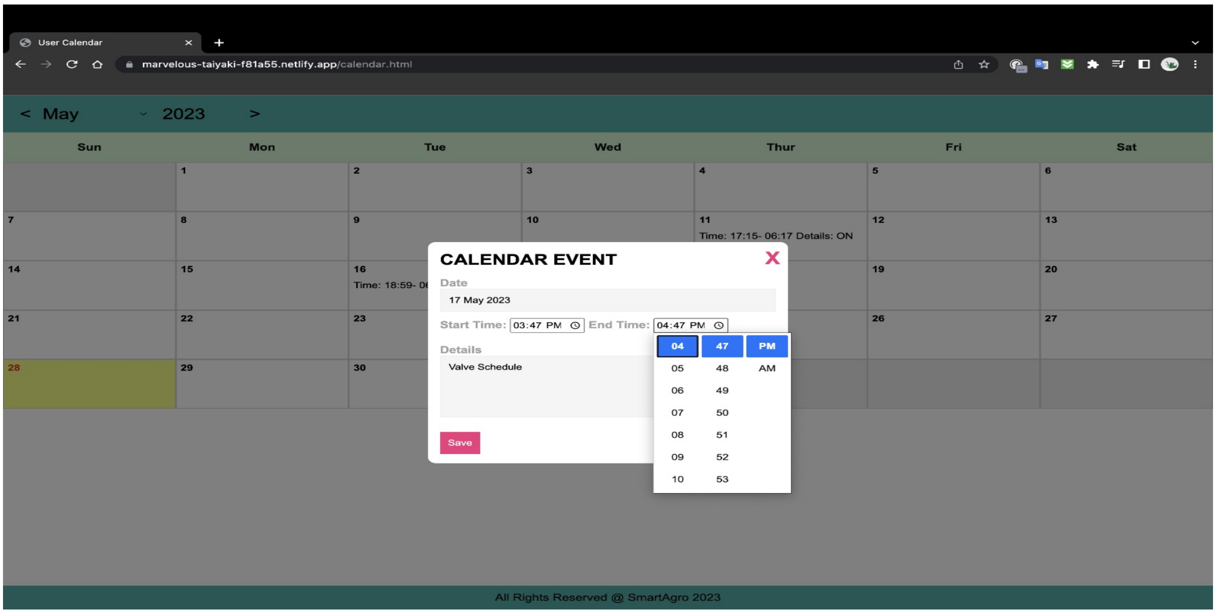


Figure 4.8: Calender event

go along more quickly and at a lower overall cost. Additionally, it enables a larger degree of creative flexibility by facilitating the easy creation of intricate geometries and individualised forms.
In addition, because just the quantity of material that is necessary for the printing process is utilised, 3D printing helps to limit the amount of material waste.
Fused deposition modelling (FDM), stereolithography (SLA), and selective laser sintering (SLS) are some of the numerous kinds of 3D printing technologies that are now accessible. Every technological advancement comes with a unique set of benefits and may be used in a variety of contexts.

It is anticipated that the continued development of the technology behind 3D printing will have a substantial influence across a variety of business sectors, paving the way for innovation, customisation, and fast prototyping. It presents an innovative approach to manufacturing, which has the potential to revolutionise the manner in which we will develop and make things in the future.

- Fusion 360 - 3D Printing Software
  Fusion 360 is essentially an engineering software programme that replicates how a machine really moves, as well as assemblies of components, mechanics, finite element analysis, complicated surfacing, rendering, and comprehensive 2D drawings based on 3D models or assemblies that are updated anytime the 3D model is changed.

- FDM Printer

  Using a thermoplastic filament, the popular 3D printing technique known as fused deposition modelling (FDM) builds things layer by layer. FDM printers are renowned for their accessibility, usability, and ability to print on a variety of materials. Users have a large selection of filaments to choose from, including PLA, ABS, and PETG, giving them versatility in a variety of applications. A 3D model is first created in CAD software, then it is divided into layers for FDM printing. These layers are converted into instructions for the printer by the printer's software. The final product is created by carefully depositing

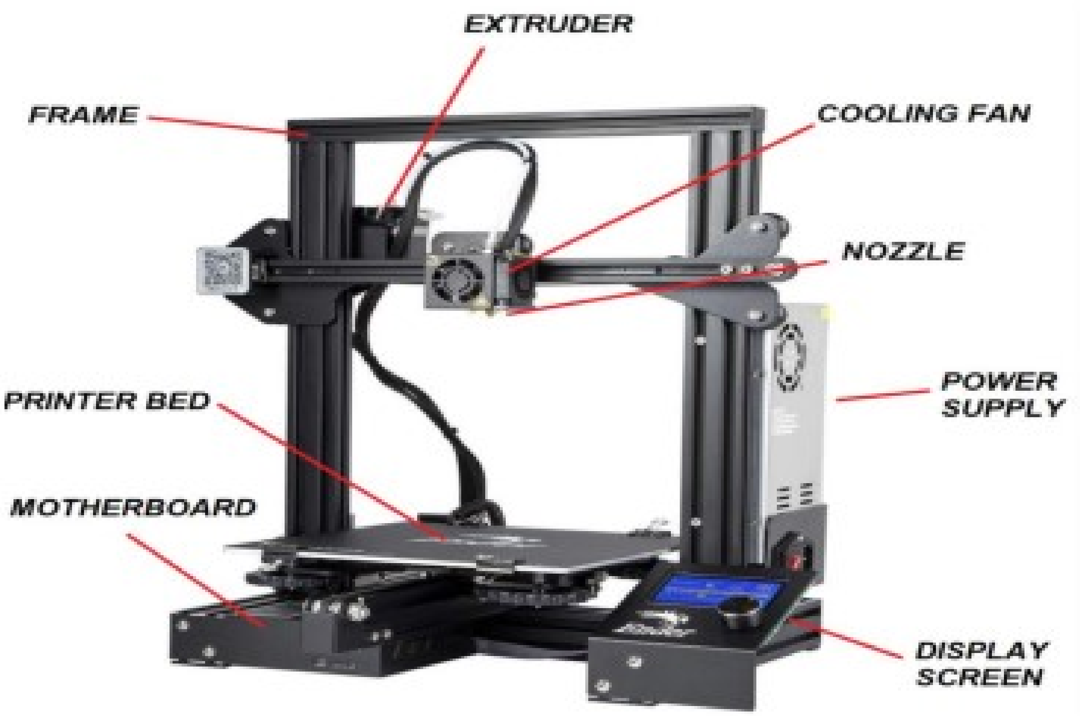


Figure 4.9: FDM Printer

and solidifying each layer using heated filament that is extruded via a nozzle. The capability of FDM printing to create sturdy items that can tolerate mechanical stress is one of its main benefits. Large build volumes are another feature that FDM printers provide, allowing for the production of substantial-sized items. FDM printing does have certain restrictions, however. Depending on printer settings and calibration, the surface polish and dimensional accuracy may not be as precise as with other technologies. Support structures can be required, and they must be taken down after printing.

- Designed Models

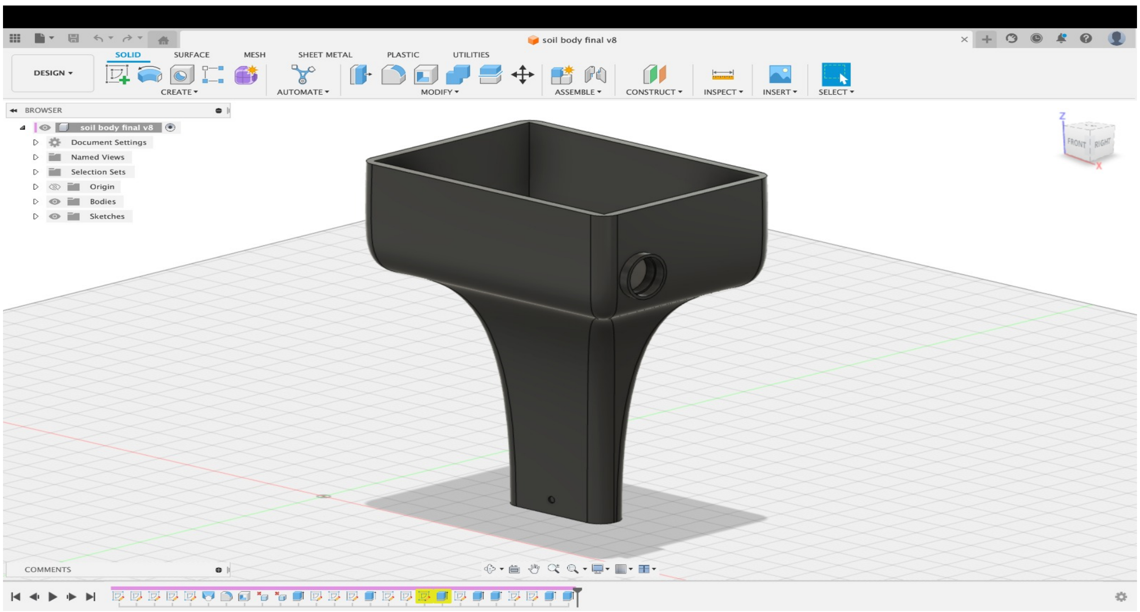


Figure 4.10: 3D Model for Soil Sensor

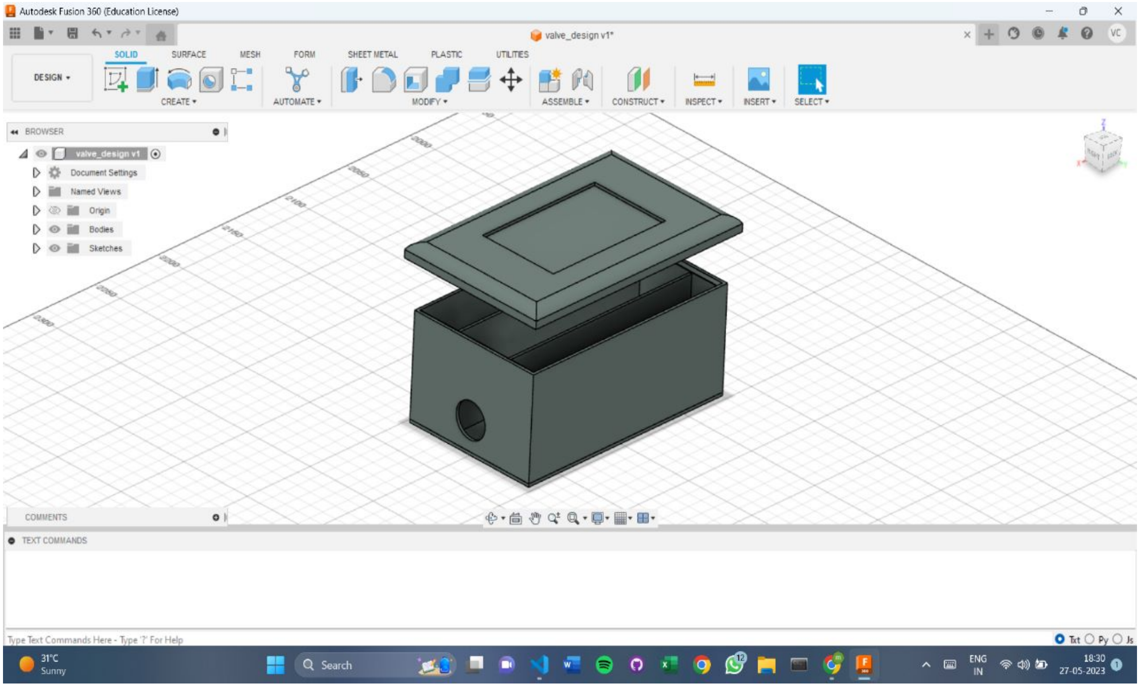


Figure 4.11: 3D Model for Smart Valve

4.6 Testing

The primary objective of this project was to implement an extensive network of soil sensors and smart valve models across multiple farms, strategically located at considerable distances from each other. This innovative approach aimed to facilitate the seamless transmission of data from remote farms to the central base station by leveraging interconnected modules.

To commence the project, we initiated a trial phase in a nearby location. After providing adequate water to the plants, we meticulously monitored the sensor data, which revealed noticeable fluctuations in moisture levels, temperature, and humidity. The smart valve, a pivotal component of the system, exhibited its remarkable capability to adjust the irrigation process based on real-time readings obtained from the soil sensor.

Encouraged by the positive results from the trial, we proceeded to subject the final model to comprehensive testing on a designated range. Throughout the testing phase, we meticulously evaluated the time required to establish a stable connection between the sensor and the base station, a crucial aspect of the model's functionality. To ensure the system's reliability and performance, we conducted range tests, rigorously examining its effectiveness within a distance of up to two hundred meters.

One of the noteworthy advantages of this model was its seamless control through a single phone call. By incorporating a GSM module, we enabled remote management and control of the base station, providing farmers and operators with the convenience of overseeing operations from a distance.

Overall, this project served as a compelling demonstration of the successful integration of soil sensors and smart valve models, enabling efficient data transmission and management across multiple farms. The ability to remotely monitor and control the entire system through a simple phone call greatly enhances the convenience and accessibility for farmers, empowering them with streamlined and effective agricultural operations

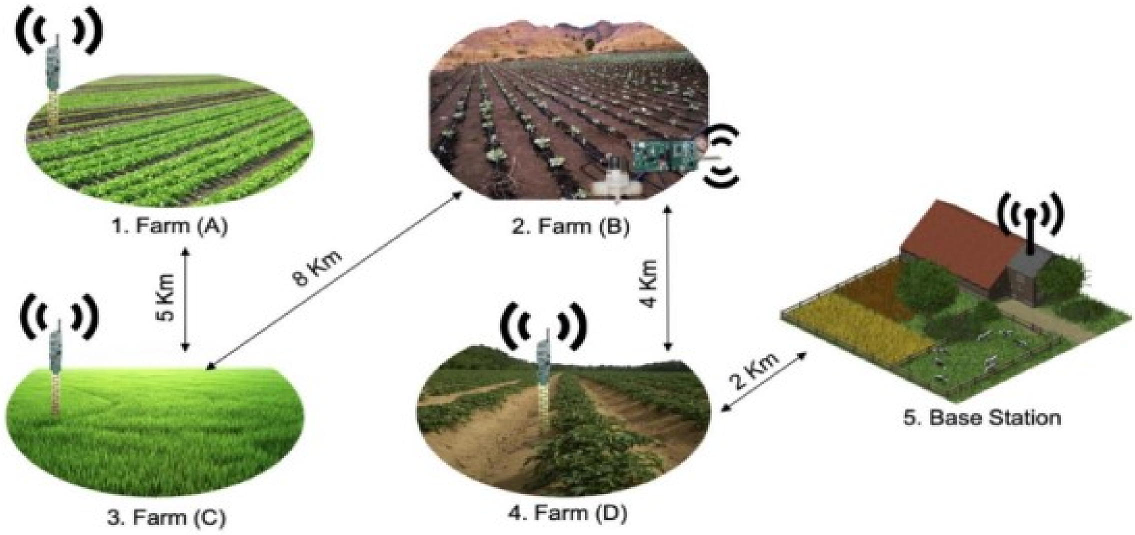


Figure 4.12: Conceptual model

Figure 4.13: Testing at nearby location

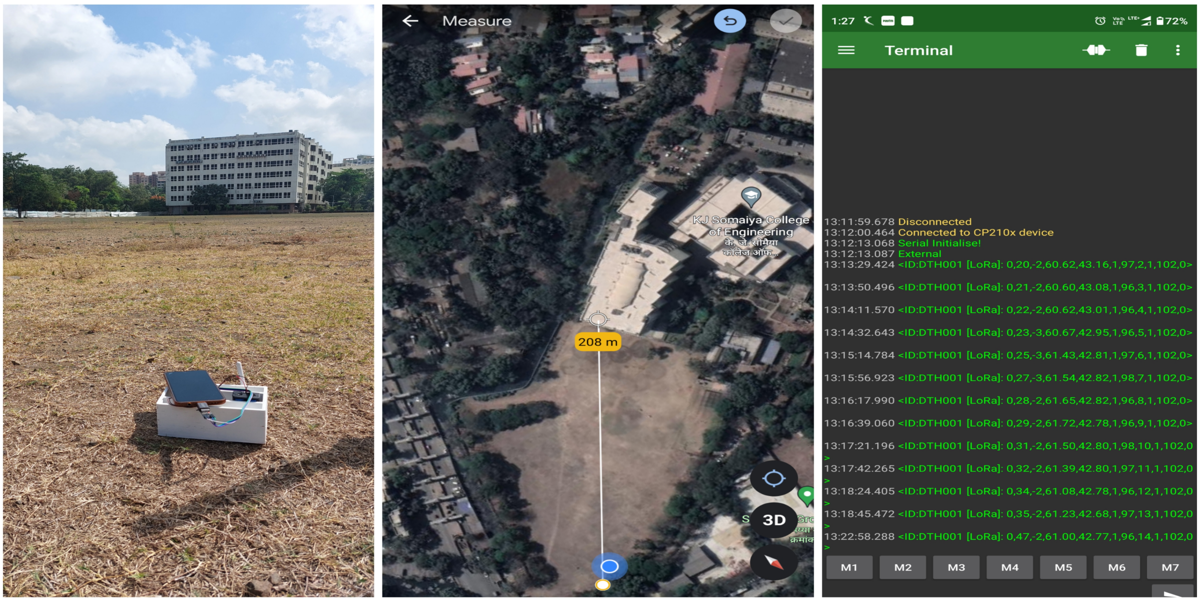


Figure 4.14: Testing in football field

Chapter 5

Conclusions and further work

This section displays the outcomes we have currently obtained as well as the project's future plans.

The developed prototype exhibits remarkable resilience by maintaining effective communication over a distance of up to 200 meters, even in challenging weather conditions. The smart valve, responsible for controlling the flow of water, and the soil sensor, designed to capture crucial information about the soil's temperature, humidity, and moisture levels, are robustly constructed to withstand harsh environments. What's more, these components are designed to harness solar energy, offering an eco-friendly and sustainable power source for continuous operation.

To enhance the usability and accessibility of the system, the base station incorporates GSM communication capabilities. This allows users to remotely control and monitor the irrigation system through a simple phone call, providing convenience and flexibility in managing irrigation operations from anywhere.

To provide real-time data insights, a dedicated website is implemented as an integral part of the system. While the utilization of Firebase's free database may introduce slight delays in data updates, the website offers a comprehensive view of key parameters such as temperature, humidity, and moisture content of the soil. Additionally, it presents statistical data and trends, enabling users to make informed decisions and optimize irrigation strategies for improved efficiency and resource utilization.

Looking towards the future, the research is actively exploring the integration of advanced machine learning algorithms into the data collected by the soil sensor. By leveraging the power of artificial intelligence, the system aims to analyze historical data, environmental factors, and crop behavior patterns to develop predictive models. This exciting development has the potential to revolutionize irrigation management by providing proactive insights, enabling farmers to anticipate crop needs, optimize irrigation schedules, and maximize yield while minimizing resource wastage.

Overall, the smart irrigation prototype showcases not only its resilience and adaptability but also its potential to revolutionize agriculture practices. By combining innovative technologies, sustainable power sources, and intelligent data analysis, the system opens up new avenues for efficient and sustainable farming, addressing the challenges of water scarcity, energy efficiency, and crop productivity in the agricultural sector.

Bibliography

[1] R. K. Kodali, M. S. Kuthada and Y. K. Yogi Borra, "LoRa Based Smart Irrigation System," 2018 4th International Conference on Computing Communication and Automation (ICCCA), 2018, pp. 1-5, doi: 10.1109/CCAA.2018.8777583.

[2] K. T. Mya, M. M. Sein, T. T. S. Nyunt, U. Lewlompaisarl and Y. Owada, "A Design for IoT Based Smart Watering System Using LoRa," 2020 IEEE 9th Global Conference on Consumer Electronics (GCCE), 2020, pp. 278-279, doi: 10.1109/GCCE50665.2020.9291936.

[3] V. A. Vu, D. Cong Trinh, T. C. TRUVANT and T. Dang Bui, "Design of automatic irrigation system for greenhouse based on LoRa technology," 2018 International Conference on Advanced Technologies for Communications (ATC), 2018, pp. 72-77, doi: 10.1109/ATC.2018.8587487.

[4] H. W. Yoon, D. J. Kim, M. Lee, C. Weon and A. Smith, "L M Farm: A Smart Farm based on LoRa MQTT," 2020 International Conference on Omni-layer Intelligent Systems (COINS), 2020, pp. 1-6, doi: 10.1109/COINS49042.2020.9191387.

[5] B. QuetÃ© et al., "Understanding the tradeoffs of LoRaWAN for IoT-based Smart Irrigation," 2020 IEEE International Workshop on Metrology for Agriculture and Forestry (MetroAgriFor), 2020, pp. 73-77, doi: 10.1109/MetroAgriFor50201.2020.9277566.

[6] S. Dasiga, A. A. R. Bhatia, A. Bhirangi and A. Siddiqua, "LoRa for the Last Mile Connectivity in IoT," 2020 9th International Conference System Modeling and Advancement in Research Trends (SMART), 2020, pp. 195-200, doi: 10.1109/SMART50582.2020.9337114.

[7] W. Zhao, S. Lin, J. Han, R. Xu and L. Hou, "Design and Implementation of Smart Irrigation System Based on LoRa," 2017 IEEE Globecom Workshops (GC Wkshps), 2017, pp. 1-6, doi: 10.1109/GLOCOMW.2017.8269115.

[8] A. Gehani, S. Harsha Shatagopam, R. Raghav, M. Sarkar and C. Paolini, "Application of 915 MHz Band LoRa for Agro-Informatics," 2021 Wireless Telecommunications Symposium (WTS), 2021, pp. 1-4, doi: 10.1109/WTS51064.2021.9433712.

[9] A. Zourmand, A. L. Kun Hing, C. Wai Hung and M. AbdulRehman, "Internet of Things (IoT) using LoRa technology," 2019 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS), 2019, pp. 324-330, doi: 10.1109/I2CACIS.2019.8825008.

[10] R. Z. Thamrin, O. N. Samijayani, S. Rahmatia, D. Adrianto and I. K. A. Enriko, "Implementation of LoRa End-Device in Sensor Network System for Indoor Application," 2020 IEEE International Conference on Communication, Networks and Satellite (Comnetsat), 2020, pp. 208-212, doi: 10.1109/Comnetsat50391.2020.9329003.

[11] Q. Zhou, K. Zheng, L. Hou, J. Xing and R. Xu, "Design and Implementation of Open LoRa for IoT," in IEEE Access, vol. 7, pp. 100649-100657, 2019, doi: 10.1109/ACCESS.2019.2930243.

[12] M. L. Liya and M. Aswathy, "LoRa technology for Internet of Things(IoT):A brief Survey," 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2020, pp. 8-13, doi: 10.1109/I-SMAC49090.2020.9243449.

Appendices

Appendix A

ATmega328p Datasheet

Atmel

ATmega328P

8-bit AVR Microcontroller with 32K Bytes In-System Programmable Flash

DATASHEET

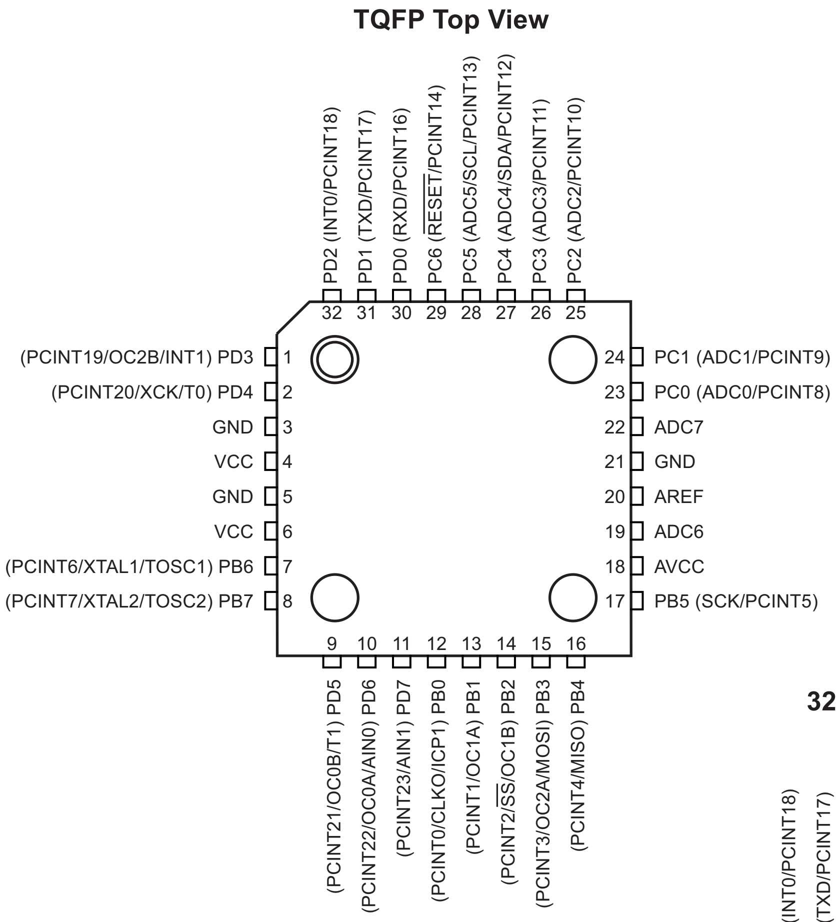
Features

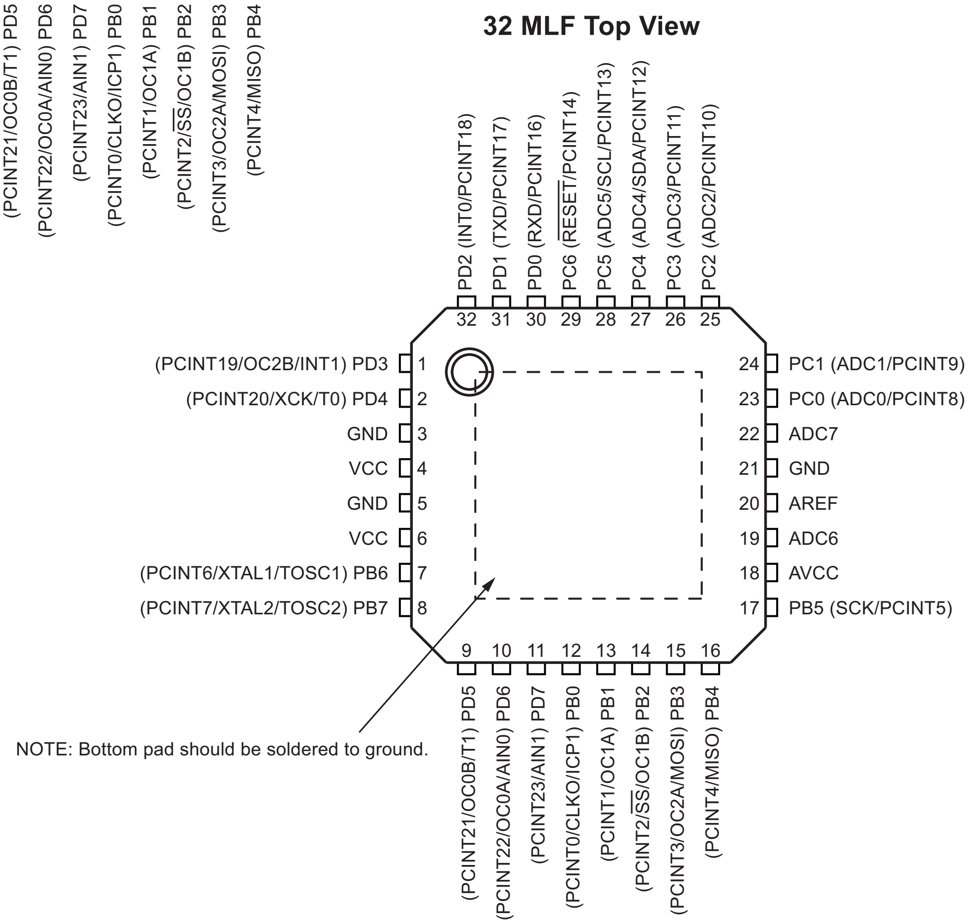
- High performance, low power AVR® 8-bit microcontroller
- Advanced RISC architecture
  - 131 powerful instructions – most single clock cycle execution
  - 32 × 8 general purpose working registers
  - Fully static operation
  - Up to 16MIPS throughput at 16MHz
  - On-chip 2-cycle multiplier
- High endurance non-volatile memory segments
  - 32K bytes of in-system self-programmable flash program memory
  - 1Kbytes EEPROM
  - 2Kbytes internal SRAM
  - Write/erase cycles: 10,000 flash/100,000 EEPROM
  - Optional boot code section with independent lock bits
    - In-system programming by on-chip boot program
    - True read-while-write operation
  - Programming lock for software security
- Peripheral features
  - Two 8-bit Timer/Counters with separate prescaler and compare mode
  - One 16-bit Timer/Counter with separate prescaler, compare mode, and capture mode
  - Real time counter with separate oscillator
  - Six PWM channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    - Temperature measurement
  - Programmable serial USART
  - Master/slave SPI serial interface
  - Byte-oriented 2-wire serial interface (Phillips I^2C compatible)
  - Programmable watchdog timer with separate on-chip oscillator
  - On-chip analog comparator
  - Interrupt and wake-up on pin change
- Special microcontroller features
  - Power-on reset and programmable brown-out detection
  - Internal calibrated oscillator
  - External and internal interrupt sources
  - Six sleep modes: Idle, ADC noise reduction, power-save, power-down, standby, and extended standby

- I/O and packages
  - 23 programmable I/O lines
  - 32-lead TQFP, and 32-pad QFN/MLF
- Operating voltage:
  - 2.7V to 5.5V for ATmega328P
- Temperature range:
  - Automotive temperature range: –40°C to +125°C
- Speed grade:
  - 0 to 8MHz at 2.7 to 5.5V (automotive temperature range: –40°C to +125°C)
  - 0 to 16MHz at 4.5 to 5.5V (automotive temperature range: –40°C to +125°C)
- Low power consumption
  - Active mode: 1.5mA at 3V - 4MHz
  - Power-down mode: 1μA at 3V

1. Pin Configurations

Figure 1-1. Pinout





9. Power Management and Sleep Modes

Sleep modes enable the application to shut down unused modules in the MCU, thereby saving power. The AVR® provides various sleep modes allowing the user to tailor the power consumption to the application's requirements.

When enabled, the brown-out detector (BOD) actively monitors the power supply voltage during the sleep periods. To further save power, it is possible to disable the BOD in some sleep modes. See Section 9.2 "BOD Disable" on page 35 for more details.

9.1 Sleep Modes

Figure 8-1 on page 24 presents the different clock systems in the Atmel® ATmega328P, and their distribution. The figure is helpful in selecting an appropriate sleep mode. Table 9-1 shows the different sleep modes, their wake up sources BOD disable ability.

Table 9-1. Active Clock Domains and Wake-up Sources in the Different Sleep Modes.

	Active Clock Domains					Oscillators		Wake-up Sources							
Sleep Mode	clk_{CPU}	clk_{FLASH}	clk_{IO}	clk_{ADC}	clk_{ASY}	Main Clock Source Enabled	Timer Oscillator Enabled	INT1, INT0 and Pin Change	TWI Address Match	Timer2	SPM/EEPROM Ready	ADC	WDT	Other/O	Software BOD Disable
Idle			X	X	X	X	X(2)	X	X	X	X	X	X	X	
ADC noise Reduction				X	X	X	X(2)	X(3)	X	X(2)	X	X	X		
Power-down								X(3)	X				X		X
Power-save					X		X(2)	X(3)	X	X			X		X
Standby[(1)]						X		X(3)	X				X		X
Extended Standby					X(2)	X	X(2)	X(3)	X	X			X		X

Notes: 1. Only recommended with external crystal or resonator selected as clock source.
2. If Timer/Counter2 is running in asynchronous mode.
3. For INT1 and INT0, only level interrupt.

To enter any of the six sleep modes, the SE bit in SMCR must be written to logic one and a SLEEP instruction must be executed. The SM2, SM1, and SM0 bits in the SMCR register select which sleep mode (idle, ADC noise reduction, power-down, power-save, standby, or extended standby) will be activated by the SLEEP instruction. See Table 9-2 on page 38 for a summary.

If an enabled interrupt occurs while the MCU is in a sleep mode, the MCU wakes up. The MCU is then halted for four cycles in addition to the start-up time, executes the interrupt routine, and resumes execution from the instruction following SLEEP. The contents of the register file and SRAM are unaltered when the device wakes up from sleep. If a reset occurs during sleep mode, the MCU wakes up and executes from the reset vector.

14. 8-bit Timer/Counter0 with PWM

14.1 Features

- Two independent output compare units
- Double buffered output compare registers
- Clear timer on compare match (auto reload)
- Glitch free, phase correct pulse width modulator (PWM)
- Variable PWM period
- Frequency generator
- Three independent interrupt sources (TOV0, OCF0A, and OCF0B)

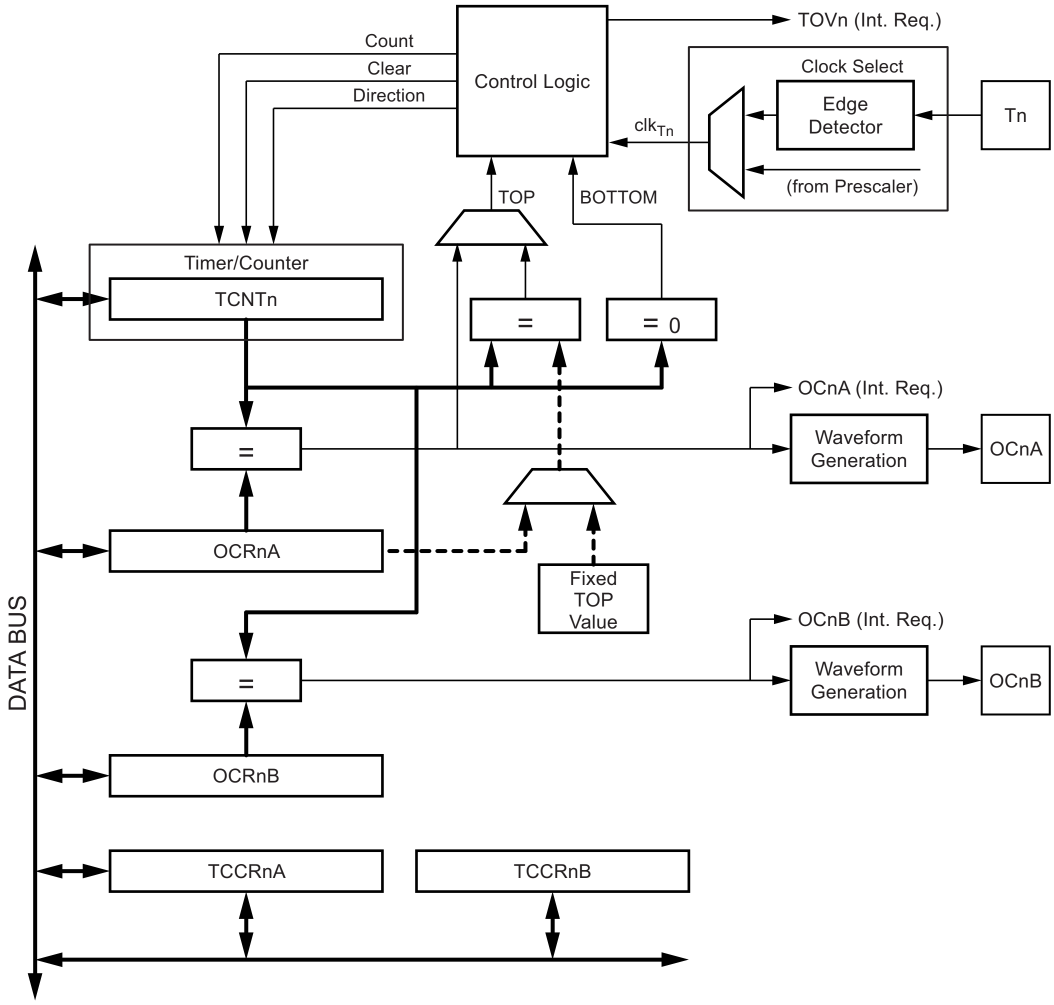
14.2 Overview

Timer/Counter0 is a general purpose 8-bit Timer/Counter module, with two independent output compare units, and with PWM support. It allows accurate program execution timing (event management) and wave generation.

A simplified block diagram of the 8-bit Timer/Counter is shown in Figure 14-1. For the actual placement of I/O pins, refer to Section 1-1 “Pinout” on page 3. CPU accessible I/O registers, including I/O bits and I/O pins, are shown in bold. The device-specific I/O register and bit locations are listed in the Section 14.9 “Register Description” on page 84.

The PRTIM0 bit in Section 9.10 “Minimizing Power Consumption” on page 36 must be written to zero to enable Timer/Counter0 module.

Figure 14-1. 8-bit Timer/Counter Block Diagram



15. 16-bit Timer/Counter1 with PWM

15.1 Features

- True 16-bit design (i.e., allows 16-bit PWM)
- Two independent output compare units
- Double buffered output compare registers
- One input capture unit
- Input capture noise canceler
- Clear timer on compare match (auto reload)
- Glitch-free, phase correct pulse width modulator (PWM)
- Variable PWM period
- Frequency generator
- External event counter
- Four independent interrupt sources (TOV1, OCF1A, OCF1B, and ICF1)

15.2 Overview

The 16-bit Timer/Counter unit allows accurate program execution timing (event management), wave generation, and signal timing measurement.

Most register and bit references in this section are written in general form. A lower case “n” replaces the Timer/Counter number, and a lower case “x” replaces the output compare unit channel. However, when using the register or bit defines in a program, the precise form must be used, i.e., TCNT1 for accessing Timer/Counter1 counter value and so on.

A simplified block diagram of the 16-bit Timer/Counter is shown in Figure 15-1 on page 90. For the actual placement of I/O pins, refer to Section 1-1 “Pinout” on page 3. CPU accessible I/O registers, including I/O bits and I/O pins, are shown in bold. The device-specific I/O register and bit locations are listed in the Section 15.11 “Register Description” on page 108.

The PRTIM1 bit in Section 9.11.3 “PRR – Power Reduction Register” on page 38 must be written to zero to enable Timer/Counter1 module.

Appendix B

L9110S Motor Control Driver

MICROCHIP

TC2117

800 mA Fixed Low Dropout Positive Regulator

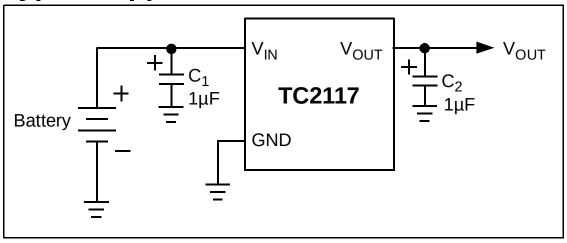
Features:

- Fixed Output Voltages: 1.8V, 2.5V, 3.0V, 3.3V
- Very Low Dropout Voltage
- Rated 800 mA Output Current
- High Output Voltage Accuracy
- Standard or Custom Output Voltages
- Overcurrent and Overtemperature Protection
- Space Saving SOT-223 Package

Applications:

- 5V to 3.3V Linear Regulator
- Portable Computers
- Instrumentation
- Battery Operated Systems
- Linear Post-Regulator for SMPS
- Core Voltage Supply for FPGAs, PLDs, CPUs and DSPs

Typical Application

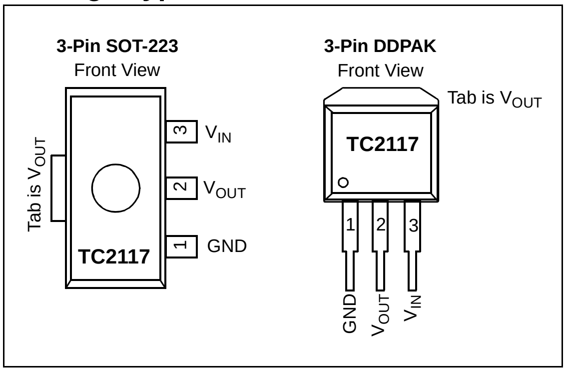


General Description:

The TC2117 is a fixed, high-accuracy (typically ±0.5%) CMOS low dropout regulator. Designed specifically for battery operated systems, the TC2117's CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current is typically 80 µA at full load (20 to 60 times lower than in bipolar regulators).

TC2117 key features include ultra low noise, very low dropout voltage (typically 450 mV at full load), and fast response to step changes in load. The TC2117 incorporates both overtemperature and overcurrent protection. The TC2117 is stable with an output capacitor of only 1 µF and has a maximum output current of 800 mA. This device is available in 3-Pin SOT-223 and 3-Pin DDPAK packages.

Package Types



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Input Voltage 6.5V
Output Voltage.................... (V_{SS} – 0.3) to (V_{IN} + 0.3V)
Power Dissipation................Internally Limited (**Note 7**)
Maximum Voltage on Any Pin ....V_{IN} +0.3V to -0.3V
Operating Temperature ....-40°C < T_J < +125°C
Storage temperature ....-65°C to +150°C

† **Notice:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, $V_{IN} = V_R$ + 1.5V, (**Note 1**), I_L = 100 µA, C_L = 3.3 µF, T_A = +25°C. **Boldface** type specifications apply for junction temperatures of -40°C to +125°C.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Input Operating Voltage	V_{IN}	**2.7**	—	**6.0**	V	Note 2
Maximum Output Current	I_{OUTMAX}	**800**	—	—	mA	
Output Voltage	V_{OUT}	**V_R – 2.5%**	V_R ± 0.5%	**V_R + 2.5%**	V	$V_R \geq 2.5V$
		V_R – 2%	V_R ± 0.5%	**V_R + 3%**		V_R = 1.8V
V_{OUT} Temperature Coefficient	$\Delta V_{OUT}/\Delta T$	—	40	—	ppm/°C	Note 3
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	—	0.007	**0.35**	%	$(V_R + 1V) \leq V_{IN} \leq 6V$
Load Regulation (**Note 4**)	$\Delta V_{OUT}/V_{OUT}$	**-0.01**	0.002	0	%/mA	I_L = 0.1 mA to I_{OUTMAX}
Dropout Voltage (**Note 5**)	$V_{IN}–V_{OUT}$	—	20	**30**	mV	$V_R \geq 2.5V$, I_L = 100 µA
		—	50	**160**		I_L = 100 mA
		—	150	**480**		I_L = 300 mA
		—	260	**800**		I_L = 500 mA
		—	450	**1300**		I_L = 800 mA
		—	1000	**1200**		V_R = 1.8V, I_L = 500 mA
		—	1200	**1400**		I_L = 800 mA
Supply Current	I_{DD}	—	80	**130**	µA	$\overline{SHDN} = V_{IH}$, I_L = 0
Power Supply Rejection Ratio	PSRR	—	55	—	db	F ≤ 1 kHz
Output Short Circuit Current	I_{OUTSC}	—	1200	—	mA	V_{OUT} = 0V
Thermal Regulation	$\Delta V_{OUT}/\Delta P_D$	—	0.04	—	V/W	Note 6
Output Noise	eN	—	300	—	$nV/\sqrt{Hz}$	I_L = 100 mA, F = 10 kHz

Note 1: V_R is the regulator output voltage setting.

2: The minimum V_{IN} has to justify the conditions: $V_{IN} \geq V_R + V_{DROPOUT}$ and $V_{IN} \geq 2.7V$ for I_L = 0.1 mA to I_{OUTMAX}.

3:
$$TCV_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) - 10^6}{V_{OUT} \times \Delta T}$$

4: Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1 mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

5: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at a 1.5V differential.

6: Thermal regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a current pulse equal to I_{LMAX} at V_{IN} = 6V for T = 10 ms.

7: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction-to-air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. Please see **Section 4.2 "Thermal Considerations"** for more details.

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