DESIGN AND IMPLEMENTATION OF AN AUTOMATIC IRRIGATION SYSTEM.

PRESENTED BY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/ELECTRONICS ENGINEERING, FALCULTY OF ENGINEERING, UNIVERSITY OF ABUJA.

IN PARTIAL FULFILLMENT OF THE REQUIREMENNMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING (B.ENG) IN ELECTRICAL/ELECTRONIC ENGINEERING

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NIGERIA.

SUPERVISED BY:

ENGR. DR. I. BEBEJI

JANUARY, 2024.

DECLARATION

I, **ONUCHE CARNEY ENYO-OJO**, hereby declare that this project work "**DESIGN AND IMPLEMENTATION OF AN AUTOMATIC IRRIGATION SYSTEM"** submitted is a record of an original work done under the guidance and supervision of ENGR. DR. I. BEBEJI. The result embodies in this project have not been submitted in any other university.

ONUCHE CARNEY ENYO-OJO **………………………..**

18245009 **Signature/Date**

CERTIFICATION

This is to certify that this project was carried out by **Onuche Carney Enyo-Ojo**, it was Designed, Simulated, Constructed, Tested, and was found to be working perfectly.

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DEDICATION

This work is dedicated to Almighty God for His superior act of Love through the course of my studies and my Parent for their financial support toward my academic pursuit and their words of advice and prayers.

ACKNOWLEDGEMENT

The pinnacle of any mortal's achievement remains a foolery without the acknowledgement of the Almighty God unchangeable supremacy. For without Him, this project would have remained a mirage. It is therefore upon this that I say Glory be to God Almighty.

My gratitude goes to my supervisor, for his intellectual prowess and empirical experiences in research works, timely dedication, hospitable supervision encouragement, constructive criticisms and useful suggestions which has definitely helped to distinguish this study among equals. Sir May the Almighty God continuous to guide and protect you. Amen

Unfailingly my most sincere appreciation to my family, my dear Mother for her guidance and motherly love and my siblings for their support. I'm indeed grateful.

To my friends, I remain grateful. When we started, we were strangers. Today, we have established true friendship. Rest assured that I will always cherish it.

APPROVAL PAGE

This project has been approved for the Department of Electrical and Electronics, Faculty of Engineering, University of Abuja.

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ABSTRACT

Irrigation is a crucial practice in agriculture, aiding in crop growth, landscape maintenance, and soil rehabilitation, especially in arid regions or during periods of low rainfall. It serves various purposes beyond agriculture, including frost protection, weed suppression, and soil consolidation prevention. Irrigation systems are automated through controllers, which allow users to set watering parameters. Two primary controller types, electric and hydraulic, are utilized, with most systems employing diaphragm valves for water control. In developing countries heavily reliant on agriculture, manual irrigation methods result in resource wastage and inefficiency, highlighting the need for automatic systems. A study has successfully designed and tested an automatic irrigation system using a microcontroller, integrating hardware components and moisture sensors to regulate water supply to plants, affirming its functionality through thorough testing.

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LIST OF ABBREVATION

AD – Anno Domini

ANN – Artificial Neural Networks

ASICs – Application Specific Integrated Circuits

AVR – Automatic Voltage Regulator

BC – Before Christ

BCE – Before the Common Era

BJT – Bipolar Junction Transistor

CE – Common Era

EEPROM – Electrically Erasable Programmable Read Only Memory

EC – Electro Conductivity

FLC – Fuzzy Logic Controller

FDR – Frequency Domain Reflectometry

FTDI – Future Technology Devices International

GPRS – General Packet Radio Service

GPS – Global Positioning System

IC – Integrated Circuit

IDE – Integrated Development Environment

LCD – Liquid Crystal Display

LEPA – Low Energy Precision Application

LED – Light Emitting Diode

MSSP – Managed Security Service Provider

PCB – Printed Circuit Board

PWM – Pulse Width Modulation

RS – Register Select

RTC – Real Time Clock

SDI – Subsurface Drip Irrigation SDI

SMPS – Switched Mode Power Supplies

SSTI – Subsurface Textile Irrigation

TDR – Time Domain Reflectometry

USART – Universal Synchronous and Asynchronous Receiver Transmitter

USB – Universal Serial Bus

VWC – Volumetric Water Content

WSN – Wireless Sensor Networks

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Irrigation entails delivering precise amounts of water to plants at specific intervals, promoting crop growth, landscape maintenance, and soil rehabilitation, particularly in dry regions or during low rainfall periods. Its benefits extend to protecting crops from frost [1], controlling weed growth [2], and preventing soil compaction [3]. Agriculture reliant solely on rain is termed rain-fed or dry land farming. Irrigation systems also serve secondary purposes such as livestock cooling, dust suppression, sewage disposal, and supporting mining activities. The study of irrigation often intersects with drainage, which deals with managing surface and sub-surface water in a given area.

With a history spanning over 5,000 years, irrigation has been a vital component of agriculture, shaping economies and societies worldwide.

An irrigation control system automates irrigation processes, including lawn sprinklers and drip systems. These systems typically allow users to set watering schedules, start times, and durations. Advanced features may include multiple programs tailored to different plant types, rain delay settings, sensor input terminals (for rain, freeze, soil moisture, and weather data), remote operation capabilities, and more.

There are two main types of controllers: electric and hydraulic. Most automatic irrigation valves utilize diaphragm valves, which require water pressure above the diaphragm to open. In hydraulic systems, controllers and valves are connected via small plastic tubes, with the controller regulating the flow of water to the valve.

In developing countries heavily reliant on agriculture, inefficient resource utilization is evident. Despite modern irrigation techniques like drip and sprinkler systems, unplanned water usage often necessitates manual watering by farmers, leading to wasted human and agricultural resources and time. Hence, there is a critical need for automatic irrigation systems, which is the primary focus of this work.

1.2 STATEMENT OF THE PROBLEM

Over the past decade, farmers have been manually conducting irrigation, typically in the morning or evening based on the immediate needs of the crops. This manual process not only consumes time and requires labour but also runs the risk of farmers occasionally forgetting to perform this crucial task. To address these challenges, an automatic irrigation system was developed. This system is designed to automatically administer water to crops, effectively minimizing the labour and time associated with traditional manual irrigation methods.

1.3 AIM AND OBJECTIVE OF THE STUDY

Aim

The primary main of this project is to construct an automated irrigation system. This system comprises a well-established integration of Arduino Uno, Water Pump, Soil Moisture Sensor, and their interconnected components.

Objectives

The design of this system is to accomplish the following goals:

- Enhance production through the implementation of an improved irrigation system.
- Effectively manage water supply for the optimal cultivation of plants.
- Minimize reliance on manpower.
- Implement proper soil condition monitoring and responsive actions through the proposed system.

The selection of a design solution took into account the following factors:

i. Installation costs;

ii. Water savings;

iii. Human intervention;

iv. Reliability;

v. Power consumption;

vi. Maintenance;

vii. Expandability.

An essential factor to consider is the installation expenses, as these costs typically dictate the practicality and feasibility of a project. The installation process should be straightforward enough for a household user. Additionally, water conservation holds significance, given the imperative to reduce excessive wastage of water and enhance water usage efficiency. With the goal of minimizing labor costs, the system should require minimal supervision and calibration. It must consistently operate with optimized efficiency, and power consumption should be closely monitored. In the case of maintenance, readily available replacement parts that are easy to install in case of failure are essential. Lastly, exploring the potential for implementing the system on a larger scale, such as in greenhouses, is recommended.

1.4 JUSTIFICATION OF THE PROJECT

The exponential growth in the world population has led to an increased demand for food, prompting the necessity for expanding cultivated land. However, changing weather patterns due to global warming make irrigation the most reliable method for crop production. As more land is brought under irrigation, there is a crucial need for the optimal utilization of water resources.

In the past few years, the application of electronics and computation has been instrumental in addressing contemporary challenges. At the forefront of this electronic revolution is the microcontroller, which, when combined with various sensors, can measure and control physical variables such as temperature, humidity, heat, and light. By employing microcontrollers to regulate these physical quantities, automatic systems have been successfully implemented.

Automation has also been extended to irrigation systems in crop production, offering a solution to the challenges posed by the unpredictable nature of climate changes and the imperative for water optimization. The automation of soil moisture sensor irrigation systems emerges as a particularly convenient, efficient, and effective method for optimizing water usage. Such systems contribute to water conservation, enabling more land to be brought under irrigation. Crops cultivated under controlled conditions exhibit improved health, resulting in higher yields. Additionally, a controlled watering system decreases the need for fertilizers, leading to decreased fertilizer costs.

1.5 SCOPE OF THE PROJECT

In this automatic water irrigation system project, we incorporated two moisture sensors to gauge the soil's moisture levels by measuring its resistance. Operating the sensors in analogue mode allows them to read values ranging from 0 to 1024. Subsequently, we calculated the mean of the values obtained from both sensors, which is then compared to predefined threshold values. These threshold values are determined through multiple sensor tests. If the sensor readings meet the condition indicating dry soil, the relay activates the water pump. Conversely, if the sensor readings signify wet soil conditions, the relay deactivates the water pump.

1.6 PURPOSE OF THE PROJECT

The primary objective of this study is to design an irrigation system that offers an automated solution for watering plants, contributing to water conservation, cost savings, and reduced human labour.

1.7 SIGNIFICANCE OF THE STUDY

1. The implementation of an automated irrigation control system enables the cultivation of cash crops, such as sugarcane, potatoes, and tobacco, which yield lucrative returns for farmers.
2. By preventing water loss through seepage, an automatic irrigation control system contributes to enhanced groundwater storage.
3. The adoption of an automatic irrigation control system leads to increased crop yields, translating to higher income for farmers and fostering prosperity in agricultural communities.
4. It is employed to support crop growth during periods of insufficient rainfall.

1.8 IMPORTANCE OF THE STUDY

1. The irrigation system sustains soil moisture, a critical factor for seed germination.
2. Water serves as a supplier of two vital elements, hydrogen and oxygen, essential for the crops.
3. Irrigation becomes indispensable for plants to absorb nutrients from the soil.
4. It plays a crucial role in fostering the growth of the roots of crop plants.

1.9 PROJECT ORGANIZATION

The structure of this work is outlined as follows: Chapter one covers the introductory section, chapter two provides a literature review, chapter three details the applied methods, chapter four delves into the work's results, and chapter five summarizes the research outcomes along with recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND OF THE STUDY

Irrigation played a crucial role in managing water in the alluvial plains of the Indus Valley Civilization. Its introduction is estimated to have begun around 4500 BC, significantly enhancing the size and prosperity of their agricultural settlements.[4] [5] [6] The civilization developed advanced irrigation and water storage systems, constructing artificial reservoirs at Girnar around 3000 BCE and establishing an early canal irrigation system around 2600 BCE. Large-scale agriculture flourished, utilizing a vast network of canals for irrigation purposes.

In the Mesopotamian plain, perennial irrigation was practiced, ensuring crops received consistent watering throughout the growing season by directing water through a network of small channels in the fields. [7] The Ancient Egyptians employed Basin irrigation, leveraging the flooding of the Nile to inundate land plots enclosed by dykes. Floodwaters were retained until fertile sediment settled before the excess was returned to the watercourse. [8] Evidence from the twelfth dynasty (approximately 1800 BCE) suggests that the ancient Egyptian pharaoh Amenemhet III utilized the natural lake of the Faiyum Oasis as a reservoir to keep water surpluses for use during dry seasons, as the lake swelled annually from Nile flooding. [9]

During the Mughal era, efforts were made to restore and develop the old Mughal irrigation system under the reign of Emperor Bahadur Shah II. The Ancient Nubians devised a form of irrigation using a waterwheel-like device called a sakia, which relied on floodwaters from the Nile River and other Sudanese rivers, dating back to the third or second millennium BCE. [10] [11] Sub-Saharan Africa saw irrigation reach the cultures and civilizations of the Niger River region by the first or second millennium BCE, relying on wet season flooding and water harvesting. [12] [14] Terrace irrigation was observed in pre-Columbian America, early Syria, India, and China. [8] Archaeological discoveries in the Zana Valley of the Andes Mountains in Peru revealed irrigation canals dating back to the 4th, 3rd, and 9th centuries BCE, [9] marking some of the earliest records of irrigation in the New World.

Ancient Persia, dating back to the 6th millennium BCE, utilized irrigation to cultivate barley in regions with insufficient natural rainfall. [15] The Qanats, developed around 800 BCE, are among the oldest known irrigation methods still which are used today, spanning across Asia, the Middle East, and North Africa. [16] The noria, a water wheel like clay pots around the rim, was introduced around the same time by Roman settlers in North Africa, later improved with valves by 150 BCE to facilitate smoother filling.[17]

The irrigation systems of ancient Sri Lanka, dating from around 300 BCE when King Pandukabhaya was reigning, continued to evolve over the next millennium. These intricate systems, including underground canals and artificial reservoirs, were primarily used for irrigating paddy fields. Many of these systems, located in Anuradhapura and Polonnaruwa, remain intact due to advanced engineering and underwent extensive restoration and expansion during the reign of King Parakrama Bahu (1153–1186 CE). [18]

2.1.1 CHINA

China's earliest hydraulic engineers, Sunshu Ao from the Spring and Autumn period (6th century BCE) and Ximen Bao from the Warring States period (5th century BCE), were pioneers in large-scale irrigation projects. In the Sichuan region, within the State of Qin in ancient China, the Dujiangyan Irrigation System, conceived by the Qin Chinese hydrologist and irrigation engineer Li Bing, was constructed in 256 BCE. This system continues to provide water for a vast farmland area today. [19] During the reign of Han Dynasty in the 2nd century AD, chain pumps were introduced in China, lifting water from lower to higher elevations. Powered by manual foot pedals, hydraulic waterwheels, or rotating mechanical wheels driven by oxen, were employed for diverse functions. These included providing water to urban residential areas, palace gardens, and primarily for irrigating farmland through canals and channels in the fields.[20] [21] [22]

In 15th century Korea, Jang Yeong-sil, an engineer from the Joseon Dynasty, invented the world's first rain gauge, known as uryanggye (Korean: 우량계), in 1441. Working in guidance of King Sejong the Great, the rain gauge was installed in irrigation tanks as part of a nationwide system designed to measure and collect rainfall for agricultural applications. This innovative instrument enabled planners and farmers to utilize gathered information more effectively in their agricultural planning. [23]

2.1.2 NORTH AMERICA

The earliest known agricultural irrigation canal system in the United States, discovered in Marana, Arizona (near Tucson) in 2009, dates back to the period between 1200 B.C. and 800 B.C.[24] This irrigation canal system predates the Hohokam culture by two thousand years and is associated with an unidentified culture. In North America, the Hohokam was the sole culture known to utilize irrigation canals for crop irrigation, sustaining the most significant population in the Southwest by AD 1300. The Hohokam employed a combination of straightforward canals and weirs in their diverse agricultural activities. From the 7th to the 14th centuries, they developed and maintained extensive irrigation networks along the lower Salt and middle Gila rivers, rivalling the complexity seen in ancient Near East, Egypt, and China. Despite lacking advanced engineering technologies, they constructed these networks with relatively simple excavation tools, achieving drops of a few feet per mile while managing erosion and siltation. The Hohokam cultivated a range of crops, including cotton, tobacco, maize, beans, squash, and various wild plants. Towards the later stages of the Hohokam Chronological Sequence, they also implemented extensive dry-farming systems, particularly for growing agave as a food and fiber source. Their reliance on canal irrigation, crucial in the challenging desert environment and arid climate, laid the foundation for consolidating rural populations into stable urban centres. [25]

2.1.3 PRESENT EXTENT

In the year 2000, the globally equipped irrigated fertile land covered a total of 2,788,000 km² (689 million acres). Asia accounted for approximately 68% of this area, the Americas for 17%, Europe for 9%, Africa for 5%, and Oceania for 1%. The largest contiguous regions with high irrigation density were identified in various locations:

- ✓ Northern India and Pakistan along the Ganges and Indus rivers
- ✓ Hai He, Huang He, and Yangtze basins in China
- ✓ Along the Nile river in Egypt and Sudan
- ✓ In the Mississippi-Missouri river basin, the Southern Great Plains, and certain parts of California

Smaller irrigated areas were dispersed across nearly all populated regions worldwide. [26]

A mere eight years later, in 2008, the sum area of irrigated land had expanded significantly to an estimated 3,245,566 km² (802 million acres), approximately equivalent to the size of India. [27]

2.2 REVIEW OF RELATED STUDIES

The exploration of models and strategies for managing plant environments began with a focus on the shoot environment, specifically the climate. This emphasis was due to the ease of measuring and controlling influential variables like temperature, humidity, irradiation, or CO2 concentration (HansP.K, 2000). The research indicates that various factors require control in the environment, with a crucial consideration being soil moisture.

Khriji et al (2014) introduced a comprehensive irrigation solution for farmers using Wireless Sensor Networks (WSN). Their automated irrigation system, utilizing cost-effective sensor nodes with low power consumption, proves effective in minimizing water wastage and cost. The deployment of Telos B mote and designated sensors/actuators, including field nodes for soil moisture and temperature detection, weather nodes for monitoring climatic changes, and actuators for controlling irrigation valve opening, contributes to efficient irrigation management.

Mahir et al (2014) proposed a systematic water usage system by implementing a solar-powered irrigation system in an orchard. Artificial Neural Networks (ANN) analyse soil moisture content to ensure even water distribution, preventing unnecessary irrigation and reducing water demand. This system achieves a significant reduction of 38% in the orchard's daily water usage and energy consumption.

Farid et al (2013) developed a practical solution for hyper-arid fields using an intelligent system. The system employs a feedback Fuzzy Logic Controller (FLC) that logs crucial field parameters through specific sensors. Integrated with a Zigbee-GPRS remote monitoring and database platform, this system operates within drip irrigation systems that been in existence, without physical modification. FLC applies fuzzy rules to determine appropriate timing and duration for irrigation.

Singh et al (2012) introduced an irrigation controller for vegetable cultivation using fuzzy logic methodology. The system adjusts water supply to plants based on size, soil moisture, affected by environmental temperature, wind velocity-induced evaporation, and water budget. Solar energy conversion technology powers the pump controller, ensuring controlled and optimal water delivery to plants.

Xin et al (2013) detailed an autonomous precision irrigation system integrating a centre pivot irrigation system with wireless underground sensor networks. This system offers autonomous irrigation management by monitoring real-time soil conditions through wireless underground sensors. Experimental trials were conducted with a hydraulic drive and continuous-move centre pivot irrigation system.

Robert (2013) advocated for a commercial wireless sensing and control network utilizing valve controlled hardware and software. The system incorporates custom node firmware, actuator hardware and firmware, an internet gateway, and communication and web interface software.

Employing a mesh network with 34 valve actuators, this system controls valves and water meters efficiently.

J.S. Awati and V.S. Patil (2014) developed an automatic irrigation control system using wireless sensor networks. The integration of sensors in a wireless monitoring network allowed for determining calibration functions and comparing the range and reaction time of sensor types in a soil l during drying. Data transmission over several kilometres was achieved, and information was made accessible through Internet access.

Nolz et al (2007) designed sensors into a wireless monitoring network to estimate and analyse calibration functions, comparing measuring ranges and reaction times of sensor types in a drying soil layer. The successful integration of sensors into the telemetry network enabled data transmission over several kilometres, accessible through Internet access.

Christos et al (2014) described the design of an adaptable decision support system integrated with a wireless sensor/actuator network for autonomous closed-loop zone-specific irrigation. Utilizing ontology to define application logic, the system emphasizes flexibility and adaptability, supported by automatic inferential and validation mechanisms. Machine learning processes induce new rules by calculating logged data sets, extracting knowledge, and expanding the system ontology for enhanced functionality.

2.3 AUTOMATIC IRRIGATION SYSTEM

An automated irrigation system operates efficiently and positively impacts its installation location. Once integrated into agricultural fields, it facilitates easy water distribution to crops and nurseries, eliminating the need for continuous human intervention. Occasionally, automated irrigation can be achieved through mechanical devices like clay pots or bottle irrigation systems. However, the implementation of irrigation systems is challenging due to their high cost and complex design. To address these challenges, we've undertaken projects in automatic irrigation system development, incorporating various technologies based on expert recommendations.

This article explores three progressively advanced automatic irrigation systems. Each system builds upon the previous one, showcasing a continuous evolution. The featured project focuses on an automatic irrigation system designed to sense soil moisture. The objective is to design a system that toggles submersible pumps on or off using relays based on soil moisture content readings.

2.4 REVIEW OF DIFFERENT TYPES OF IRRIGATION

Various irrigation methods employ different techniques to supply water to plants. The primary objective is to achieve uniform water distribution, ensuring each plant receives the appropriate amount—neither excessive nor insufficient.

2.4.1 SURFACE IRRIGATION

Surface irrigation, the most ancient form, has been practiced for thousands of years. In systems such as furrow, flood, or level basin irrigation, water traverses the surface of agricultural lands, wetting and infiltrating the soil. This method, often termed flood irrigation when flooding occurs, historically dominated global agriculture and is still prevalent worldwide. In terraced rice fields, water levels are regulated by dikes, often filled with soil, to flood or regulate distinct fields. Surface irrigation, while historically significant, generally exhibits lower water application efficiency compared to other methods. It is even employed for landscaping purposes in specific regions, such as Phoenix, Arizona, where water delivery follows a predefined schedule set by a local irrigation district. [36]

2.4.2 MICRO-IRRIGATION

Micro-irrigation, also known as localized or trickle irrigation, operates with low-pressure water distribution through a piped network. Systems like traditional drip irrigation, subsurface drip irrigation (SDI), micro-spray, micro-sprinkler irrigation, and mini-bubbler irrigation fall under this category. [37] In drip irrigation, water is released drop by drop directly at the roots, minimizing evaporation and runoff. When managed effectively, drip irrigation can be the most water-efficient method, boasting field water efficiency typically ranging from 80 to 90 percent. [38] Modern agricultural practices often integrate drip irrigation with plastic mulch to further reduce evaporation, and it serves as a conduit for fertilizer delivery in a process known as fertigation. Drip irrigation methods span a spectrum from sophisticated and computerized to simple and labor-intensive. While low water pressures are generally required, pressure compensating emitters are available, allowing for non-level fields. High-technology solutions include precisely calibrated emitters connected to a computerized valve system through tubing lines.

These methods showcase the diverse approaches to irrigation, each with its own advantages and considerations, contributing to efficient water management in agriculture.

2.4.3 SPRINKLER IRRIGATION

In sprinkler or overhead irrigation systems, water is conveyed through pipes to centralized locations in the field and then distributed using high-pressure sprinklers or guns positioned overhead. A setup with sprinklers, sprays, or guns mounted on permanently installed risers is commonly categorised to as a solid-set irrigation system. Rotors, driven by a ball drive, gear drive, or impact mechanism, are higher-pressure sprinklers that can rotate in a full or partial circle. Guns, operating at pressures of 275 to 900 kPa (40 to 130 psi) with flows ranging from 3 to 76 L/s (50 to 1200 US gal/min) and nozzle diameters between 10 to 50 mm (0.5 to 1.9 in), serve various purposes, including irrigation, industrial applications such as dust suppression, and logging.

Sprinklers can also be build non mobile platforms fastened to the water source by a hose. Automated moving wheeled systems, known as travelling sprinklers, can irrigate areas like subsidiary farms, parks, pastures, sports fields, and cemeteries without human intervention. Typically, these systems employ a length of polyethylene tubing mount on a steel drum, powered by either irrigation water or a small gas engine. As the tubing is mounted on the drum, the sprinkler is controlled across the field. When the sprinkler returns to the reel, the system shuts down. This setup, widely known as a "water reel" travelling irrigation sprinkler, finds extensive use in dust suppression, irrigation, and the land application of wastewater.

2.4.4 CENTRE PIVOT

Centre pivot irrigation represents a form of sprinkler irrigation involving interconnected segments of pipes (usually galvanized steel or aluminium) supported by trusses, mounted on wheeled towers. Sprinklers are positioned along the length of the system, allowing it to move in a circular pattern and receive water from the pivot point at the centre of the arc. [39] These systems are utilized globally and facilitate irrigation across various terrains. Modern centre pivot systems often incorporate drop sprinkler heads, which hang from a U-shaped pipe attached to the top of the main pipe. Placed a few feet above the crops, these heads help limit evaporative losses. Drops may also be utilized with drag hoses or bubblers that deposit water directly on the ground between crops. The circular planting of crops conforming to the centre pivot is known as Low Energy Precision Application (LEPA). Initially water-powered, most centre pivots have transitioned to hydraulic or electric-motor-driven systems, with many modern systems featuring GPS devices. [40]

2.4.5 LATERAL MOVE IRRIGATION (SIDE ROLL, WHEEL LINE, WHEEL MOVE)

This irrigation method involves a set of pipes, each with a wheel approximately 1.5 m in diameter permanently affixed to its midpoint, along with sprinklers distributed along its length. [41] These pipes are interconnected, and water is supplied at one end through a large hose. Once a sufficient amount of irrigation has been administered to a single strip of the field, the hose is detached, the water is drained from the system, and the apparatus is either manually or mechanically rolled to relocate the sprinklers throughout the field. Subsequently, the hose is reattached, and this sequence is reiterated in a systematic manner until the entire field has been irrigated.While this system is cost effective to install than a centre pivot, it is more labour-intensive to operate. It doesn't automatically traverse the field but applies water in a stationary strip, requiring drainage before rolling to a new strip. Typically utilizing 100 or 130 mm (4 or 5 inches) diameter aluminium pipes, the pipe serves as both water transport and an axle for rotating all the wheels. [42] A drive system, often located close to the centre of the wheel line, turns the clamped-together pipe sections as a single axle, facilitating the rolling of the entire wheel line. Manual adjustment of individual wheel positions may be necessary if misalignment occurs.

Wheel line systems have limitations on water capacity and the height of crops that can be irrigated. An advantageous feature is the system's ability to be easily disconnected into sections, adapting to field shape as it moves. It is commonly employed in small, rectilinear, or oddly-shaped fields, hilly or mountainous regions, or areas where labour costs are lower.

2.4.6 LAWN SPRINKLER SYSTEMS

Permanent lawn sprinkler systems, unlike portable hose-end sprinklers, are fixtures commonly found in residential lawns, commercial landscapes, as well as various public and recreational spaces like places of worship, schools, public parks, cemeteries, and golf courses. To preserve the visual appeal, most components of these systems are concealed underground. Typically, a standard lawn sprinkler system consists of multiple zones, each covering a specific area of the landscape, constrained by the capacity of the water source. These landscape segments are typically categorized based on microclimate, plant types, and irrigation equipment.

Although manual systems are still in use, most lawn sprinkler systems can be automated using an irrigation controller, also known as a clock or timer. Automatic systems commonly employ electric solenoid valves, with each zone having one or more of these valves connected to the controller. Upon activation by the controller, the valve opens, allowing water to flow to the sprinklers in that zone.

There are two primary types of sprinklers utilized in lawn irrigation: pop-up spray heads and rotors. Spray heads cover smaller areas with a fixed spray pattern, while rotors, featuring rotating streams, are suitable for larger areas. On golf courses, rotors can be substantial, often combined with a valve in a single sprinkler unit, known as a 'valve in head.' In turf areas, sprinklers are installed flush with the ground surface, popping up when pressurized to water the designated area until the valve closes. Upon release of pressure in the lateral line, the sprinkler head retracts into the ground. In flower beds or shrub areas, sprinklers may be mounted on above-ground risers or taller pop-up sprinklers, installed flush, similar to lawn areas.[43]

2.4.8 HOSE-END SPRINKLERS

Numerous varieties of hose-end sprinklers are available, with many being scaled-down versions of larger agricultural and landscape sprinklers specifically designed to function with a standard garden hose. Some feature a spiked base for temporary insertion into the ground, while others incorporate a sled base intended to be pulled along while attached to the hose.

2.4.9 SUB IRRIGATION

Sub irrigation, extensively utilized in field crops in regions with high water tables, entails artificially elevating the water table to hydrate the soil beneath the root zone of plants. Typically employed in permanent grasslands located in low-lying areas or river valleys, sub irrigation systems are integrated with drainage infrastructure. This system includes a network of pumping stations, canals, weirs, and gates that regulate the water level in ditches, thereby controlling the water table.

Commercial greenhouse cultivation also adopts sub irrigation, especially for potted plants. In this method, water is supplied from below, absorbed upward by the plants, and any excess water is collected for recycling. The process involves temporarily flooding a container or flowing through a trough with a water and nutrient solution for a short duration (10–20 minutes), followed by pumping the water back into a holding tank which are resuable. [44] Sub irrigation in greenhouses requires sophisticated and costly equipment and management. Its main advantages include water and nutrient conservation, as well as labour savings due to reduced system maintenance and increased automation. This approach is akin to subsurface basin irrigation.

2.4.10 SELF-WATERING CONTAINER (SUB-IRRIGATED PLANTER)

Another form of sub irrigation is the self-watering container, also known as a sub-irrigated planter. This setup includes a planter suspended on a reservoir featuring a wicking material like a polyester rope. Water ascends the wick through capillary action, providing moisture to the plants.

2.4.11 SUBSURFACE TEXTILE IRRIGATION (SSTI)

Subsurface Textile Irrigation (SSTI) is a technology specifically developed for sub irrigation across various soil types, from arid sands to dense clays. A typical SSTI system consists of several layers: an impermeable base layer usually made of polyethylene or polypropylene, with a drip line running along it, followed by a geotextile layer above the drip line, and finally, a narrow impermeable layer on top of the geotextile. Unlike conventional drip irrigation, the spacing of emitters in the drip pipe is not crucial, as the geotextile transports water along the fabric, reaching up to 2 meters from the dripper. The impermeable layer effectively creates an artificial water table.

2.5 WATER SOURCES

Sources of irrigation water encompass diverse origins, such as groundwater, which is procured from springs or wells, surface water drawn from rivers, lakes, or reservoirs, and non-conventional alternatives like treated wastewater, desalinated water, drainage water, or the collection of fog. Spate irrigation (floodwater harvesting), represents a distinctive form of surface water irrigation. During floods (spates), water is redirected to typically dry river beds (wadis) through a network of dams, gates, and channels, covering expansive areas. The retained moisture in the soil becomes instrumental for cultivating crops, and spate irrigation is particularly prevalent in semi-arid or arid, mountainous regions. While floodwater harvesting is acknowledged as an established irrigation method, rainwater harvesting is typically not classified as a form of irrigation. Rainwater harvesting involves gathering runoff water from roofs or unused land.

Globally, around 90% of wastewater remains untreated, contributing significantly to widespread water pollution, particularly in low-income countries. Agriculture is increasingly resorting to untreated wastewater for irrigation, driven by the lucrative markets for fresh produce in urban areas. However, competition for water resources among agriculture, industry, and municipalities, coupled with water scarcity concerns, often compels farmers to utilize water contaminated with urban waste, including sewage. This practice poses significant health risks, particularly when people consume raw vegetables irrigated with polluted water. [45] The

International Water Management Institute has undertaken projects in various countries to assess and mitigate the risks associated with wastewater irrigation, promoting a 'multiple-barrier' approach that encourages farmers to adopt risk-reducing practices.

The utilization of recycled water for irrigation offers numerous advantages, including cost-effectiveness, consistent supply irrespective of season or water restrictions, and overall quality uniformity. Recycled wastewater irrigation is also viewed as a method for plant fertilization and nutrient supplementation. However, it carries the risk of soil and water pollution through excessive wastewater application, necessitating a comprehensive understanding of soil water conditions for effective utilization. [46]

In regions where humid air condenses onto cold surfaces at night, water can be obtained. This practice is observed in Lanzarote's vineyards, where stones are used to condense water. Fog collectors, constructed from canvas or foil sheets, are also employed for water collection. Additionally, the condensate from air conditioning units is increasingly utilized as a water source in large urban areas

2.6 NEED FOR AUTOMATIC IRRIGATION

Automated irrigation systems offer a high level of convenience, particularly for individuals who frequently travel. When installed and programmed accurately, these systems also contribute to cost savings and water conservation efforts. The expense associated with replacing dead lawn grass and plants can be significant, but the advantages of automatic irrigation extend further. Traditional watering methods using hoses or oscillators are inefficient and wasteful of water resources. Unlike these methods, automatic irrigation systems can be precisely programmed to deliver specific amounts of water directly to targeted areas, ensuring a more efficient and conservation-oriented approach to watering plants with precision at their roots.

In 2016, a study discovered that nations relying on irrigation-based agriculture exhibit a higher likelihood of having autocratic systems compared to those with alternative agricultural practices. According to the study's authors, the historical background of this phenomenon lie in the ability of landed elites in arid regions to monopolize water and fertile land due to the advent of irrigation. This concentration of resources empowered elites, enhancing their influence and capacity to resist democratization efforts. [47]

CHAPTER THREE

3.0 CIRCUIT DESIGN AND ANALYSIS

3.1 METHODOLOGY

The methods used for the implementation of the aims and objectives of this study are described as follows: The data for the research of this study were obtained both from primary and secondary sources. Primary data were collected from various knowledge on the practical application of electrical electronics engineering, lectures notes and by consulting more experience persons on the electrical discipline and general knowledge on electricity. Secondary data on the other hand were obtained by searching on the internet and text books.

3.2 BLOCK DIAGRAM

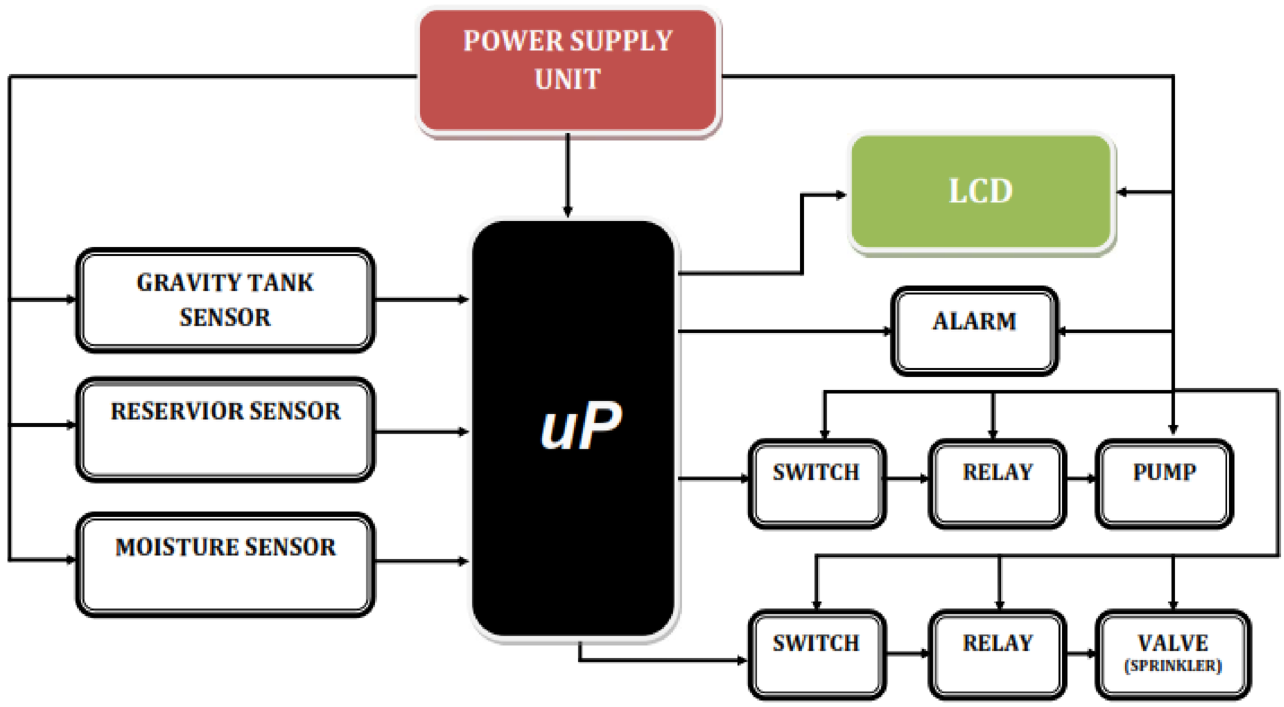


Figure 3.1: Block Diagram

3.2.1 Block Diagram Description

In this project, there are three key components in operation as shown in the figure above: moisture sensors, a gravity tank & reservoir sensor, and a motor/water pump. The Arduino Board is programmed through the Arduino IDE software to facilitate their coordination. The primary role of the moisture sensor is to gauge the soil's moisture level, while the motor/water pump is responsible for delivering water to the plants.

To control the motor, an Arduino Uno is employed. Refer to the schematic for proper connection of the Arduino to the motor driver, and subsequently, the driver to the water pump. The motor can be operated at 230 volts. The moisture sensor continually measures soil moisture and transmits a signal to the Arduino when watering is necessary. The motor/water pump then irrigates the plants until the desired moisture level is achieved.

3.3 CIRCUIT ANALYSIS

The following are the components used;

1. Power supply (Lithium battery 9 Volts)
2. Micro-controller (Atmega 328)
3. Sensor
4. Water Pump
5. Transistor
6. Diode
7. Resistor
8. Potentiometer
9. Capacitor
10. Liquid Crystal Display (LCD)
11. Relay
12. LED
13. Boost Converter
14. Dot Board
15. Jumper wires
16. A computer for programming

3.3.1 POWER SUPPLY

Electric power is the measure of electron movement generating energy. In the era of electronics, numerous devices require electrical power for specific functionalities. However, the ability to control electrical power is not without its expenses. In the contemporary world, cost is always a critical consideration. Power supplies serve as instruments capable of managing electrical power for diverse applications. While some power supplies can be costly, there are more economical alternatives that yield comparable results. A power supply involves conversion processes and must be dependable enough to avoid causing harm to connected devices. Achieving this reliability requires specific components arranged in particular configurations to generate the desired outputs.

Design of Power Supply (12V & 5V Combo power supply)

Each circuit operates at a distinct voltage, with some running on 5V, 9V, and so forth. However, for this particular project, we will exclusively utilize 5V and 12V. If employing an ATMEGA 16-bit microcontroller, it is imperative to have a 5V power supply since the operating voltage for the ATMEGA 16 microcontroller is 5V. Providing a voltage exceeding 5V may result in damage to your microcontroller. To prevent this potential damage, it is essential to consistently employ a 5V power supply for circuits involving microcontrollers.

3.3.2 MICROCONTROLLER

The Arduino Uno is a microcontroller board centered around the ATmega328, as illustrated in figure 3.3. It features 14 digital input/output pins (with 6 designated as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button, as depicted in figure 3.2, providing all the necessary components to support the microcontroller. To get started, it can be easily connected to a computer using a USB cable or powered via an AC-to-DC adapter or battery.

Setting it apart from its predecessors, the Uno departs from the use of the FTDI USB-to-serial driver chip. Instead, it incorporates the Atmega16U2 (Atmega8U2 until version R2), which is programmed as a USB-to-serial converter.

Features of ATMEGA 328:

i. 28-pin AVR Microcontroller

ii. Flash Program Memory: 32 Kbytes

iii. EEPROM Data Memory: 1 Kbytes

iv. SRAM Data Memory: 2 Kbytes

v. I/O Pins: 23

vi. Timers: Two 8-bit / One 16-bit

vii. A/D Converter: 10-bit Six Channel

viii. PWM: Six Channels

ix. RTC: Yes with Separate Oscillator

x. MSSP: SPI and I^{2}C Master and Slave Support

xi. USART: Yes

xii. External Oscillator: up to 20MHz

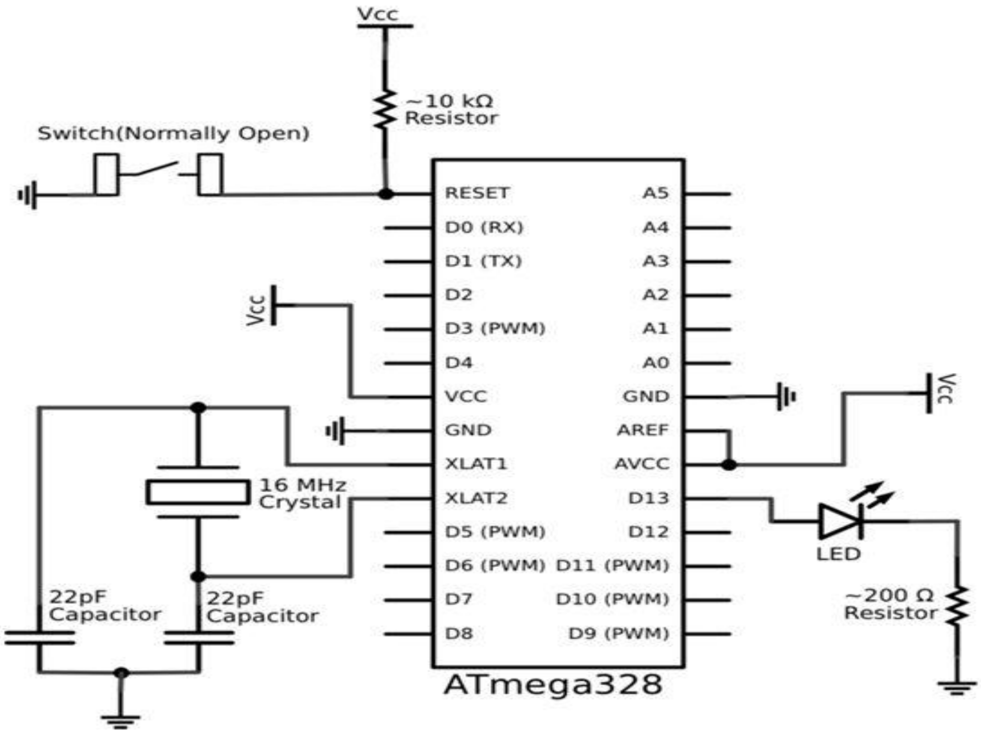


Figure 3.2 ATMEGA 328 (Pin Configuration)

Physical Characteristics of ATMEGA 328

The Uno PCB has a maximum length and width of 2.7 and 2.1 inches, respectively, with the USB connector and power jack extending beyond the former dimension. The board features four screw holes for secure attachment to a surface or case. Notably, the spacing between digital pins 7 and 8 is 16 mil (0.16"), deviating from the even multiple of 100 mil spacing found in other pins.

Versatile for interfacing with various components, the Arduino Uno board stands out as an excellent choice for beginners. Powered by the ATMEGA328 microcontroller and equipped with 14 I/O pins, the Arduino Uno has gained popularity in the realms of robotics and electronics. In this context, we explore valuable tutorials covering topics ranging from the initial setup of the Arduino Uno to basic tasks like blinking an LED, and even advanced projects like wirelessly controlling a robot with an Android phone. This article serves as a comprehensive starting point and introduction to the Arduino Uno board.

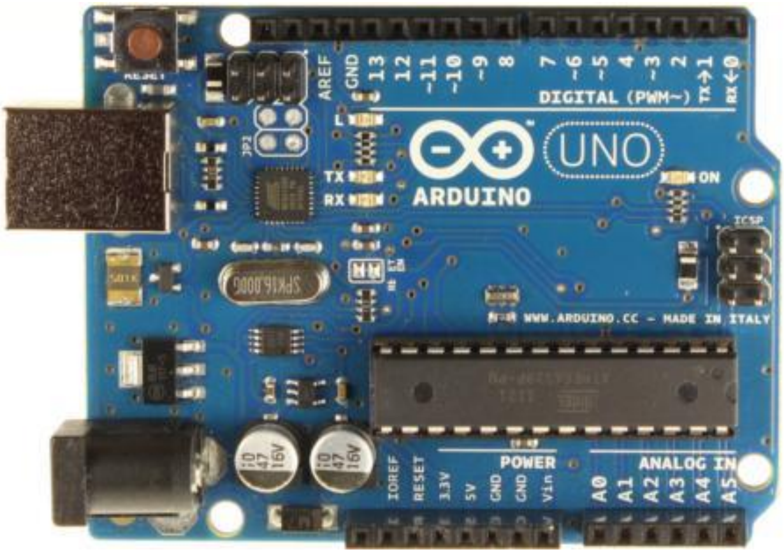


Figure 3.3: Arduino Uno

Steps of Using Arduino IDE

Step 1:

Arduino microcontrollers come in various types, with the Arduino UNO being the most common, alongside specialized variations. Before initiating your project, conduct some research to determine the most suitable version for your specific needs.

Step 2:

To commence, install the Arduino Programmer (the integrated development environment IDE).

Step 3:

The Arduino is connected to the computer's USB port, using a specific USB cable if required. Each Arduino has a distinct virtual serial-port address, so if different Arduinos are used, reconfigure the port accordingly.

Step 4:

Configure the board type and serial port settings in the Arduino Programmer.

Step 5:

Verify the functionality of the microcontroller by using preloaded programs, referred to as sketches, within the Arduino Programmer. Open an example sketch, press the upload button, and observe the Arduino's response; for instance, if the sketch involves blinking an LED light, the light should begin blinking.

Step 6:

For uploading new code to the Arduino, either access code to paste into the programmer or write your own using the Arduino programming language to create a custom sketch. An Arduino sketch typically comprises five parts: a header describing the sketch and its author, a section defining variables, a setup routine establishing initial variable conditions and executing preliminary code, a loop routine for the main repeating code, and a section for additional functions activated during the setup and loop routines. All sketches should include the setup and loop routines.

Step 7:

Once the new sketch is uploaded to the Arduino, it is then disconnected from the computer and integrated into the project according to instructions.

Step 8:

Initiate the program by clicking the "Upload" button in the environment. Wait for a few seconds, during which the RX and TX LEDs on the board may flash. If the upload is successful, the status bar will display the message "Done uploading."

3.3.3 SENSOR

An electrical resistance sensor as shown in figure 3.4 is designed to gauge soil moisture levels. Consisting of two electrodes, this sensor operates by passing a current through the soil and assessing the resistance encountered. The moisture content surrounding the sensor influences the resistance, with higher water levels resulting in lower resistance and increased current flow. Conversely, lower soil moisture leads to a higher resistance level in the sensor module output. Notably, this sensor provides both digital and analog outputs, with the digital output being simpler to use but less precise than the analog output.

Typically embedded within some form of insulation, soil moisture sensors serve as sensing devices. This insulation often serves electrical purposes, isolating the sensor electrically. These sensors, crucial for measuring water content in soil, are frequently part of a soil moisture probe comprising multiple sensors.

Various technologies find application in soil moisture sensors, including frequency domain sensors like capacitance sensors, neutron moisture gauges leveraging water's moderator properties for neutrons, and the measurement of electrical resistance in the soil.

For our specific project, we will utilize moisture sensors designed for insertion into the soil, enabling accurate measurement of soil moisture content which specifications is listed in table 3.1.

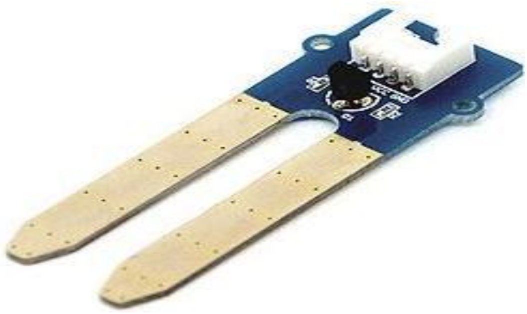


Figure 3.4: sensor

The measurement of soil electrical conductivity involves the placement of two metal conductors spaced apart in the soil. However, this method encounters challenges when dissolved salts significantly alter water conductivity, potentially affecting the accuracy of measurements. An economical solution involves embedding conductors within a porous gypsum block, releasing calcium and sulphate ions to surpass the soil's background ion levels. The water absorbed by the block correlates with soil water potential within the range of -60 to -600 kPa, offering a tertiary indicator suitable for medium to heavy soils.

Alternatively, non-dissolving granular matrix sensors are now available, featuring a more precise specification for the range of 0 to -200 kPa. These sensors employ internal calibration methods to counter variations caused by solutes and temperature.

Methods that leverage soil dielectric properties essentially measure proxy variables, encompassing a component linked to soil electrical conductivity. Consequently, these methods inherently respond to variations in soil salinity, temperature, and water content. Measurements are further influenced by soil bulk density and the ratio of bound to free water, influenced by the soil type. Despite these factors, specific conditions allow for achieving high accuracy and precision, and certain sensor types have gained widespread adoption in scientific research.

Functional Description of Sensor

1. To convert the change in resistance into a change in voltage, the sensor is linked with a 200kΩ resistor in series, establishing a potential divider arrangement.
2. The sensor provides a voltage output that correlates with the soil's conductivity. Soil conductivity is contingent on its moisture content, increasing with higher water levels. Consequently, blocks with elevated water content exhibit lower electrical resistance.
3. The voltage output is extracted from the circuit's output terminal, with the moisture sensor submerged into the soil specimen undergoing moisture content testing.

The soil underwent examination in three distinct conditions:

3.3.3.1 Dry Condition

The sensor is positioned in the soil under dry conditions, penetrating to a considerable depth. In the absence of a conduction path between the two copper leads, the sensor registers a high resistance value (approximately 700 kΩ). The voltage output from the potential divider in this scenario ranges from 2.2 V to a lower optimum level of 3 V.

3.3.3.2 Optimum Condition

Upon adding water to the soil, it permeates through successive layers, propelled by capillary force, elevating the soil's moisture content. This establishes a conductive path between the copper leads, resulting in a reduced sensor resistance. The optimum condition can be manually set based on the soil type.

3.3.3.3 Excess Wet Condition

Beyond the optimum moisture level, there is a significant surge in soil conductivity, causing the sensor resistance to further decrease to around 50kΩ. The voltage output from the potential divider in this instance ranges from the upper optimum level of 5V to 10V.

In general, translating raw sensor readings to volumetric moisture content or water potential involves secondary or tertiary methods. These conversions are often specific to the sensor or soil, influenced or hindered by high salinity levels and temperature dependencies. Research-grade instruments typically exhibit laboratory-measured accuracy worse than +/- 4% using factory settings or as good as +/- 1% when calibrated for the specific soil.

Sensors based on the Time Domain Reflectometry (TDR) method seem to require minimal calibration but may not be suitable for soils with very high salinity or clay content. Granular matrix sensors lack comparable laboratory specifications, potentially due to calibration challenges, slower response times, and hysteresis in wetting and drying curves.

Soil dielectric measurement is a preferred method in most research studies where expertise is available for calibration, installation, and interpretation. However, cost reduction through sensor multiplexing is constrained by stray capacitances. Lower manufacturing costs are conceivable through Application Specific Integrated Circuits (ASICs) development, though this necessitates substantial investment. Multiple sensors are essential for a depth profile and representative area coverage, but costs can be minimized by employing a computer model to extend measurements predictively. Thus, utilizing moisture sensors underscores the paramount importance of reliable, cost-effective sensors and electronic systems for accessing and interpreting the data.

Table 3.1: Soil Moisture Sensor Specifications

Name	Specification
Vcc power supply	3.3V or 5V
Current	35mA
Signal output voltage	0 - 4.2V
Digital Outputs	0 or 1
Analog	Resistance (Ω)
Panel Dimension	3.0cm by 1.6cm
Probe Dimension	6.0cm by 3.0cm
GND	Connected to ground

Irrigation stands out as the pivotal cultural practice and a labour-intensive task in daily greenhouse operations. The crucial aspects of irrigation involve determining when and how much water is needed. To automate this process, various sensors and methods exist to gauge the water requirements of plants, as suggested by Dr. Peter Ling in 2005.

For this project, the recommendation is to employ a soil moisture detector for irrigation, with two viable options being the tensiometer and the dielectric sensor. The advantage of a tensiometer lies in its resilience to the temperature of the soil water solution and the osmotic potential, allowing salts to move freely in and out of the ceramic cup. Consequently, tensiometer readings remain unaffected by electro-conductivity (EC) or soil temperature. However, it's important to note that this type of sensor requires periodic maintenance. In dry environments, where the tensiometer becomes a source of seeping water in drier surrounding soil, the water in the tensiometer cavity needs regular refilling.

Soil Moisture Equation

A soil moisture sensor is use to measure the volumetric water content (VWC) of soil. Mathematically VWC, θ, is given as follows;

$$\theta = \frac{V_w}{V_T} \quad \ldots\ldots\text{ eqn i}$$

Where: $V_w$is the water volume and

V_T is the total volume (soil volume + water volume).

Soil moisture sensors are categorized based on their approach to measuring soil moisture content, with two primary methods employed to ascertain volumetric water content (VWC): direct and indirect. In the direct method, a specified soil volume is dried in an oven and then weighed. The determination of VWC through the direct method involves the following mathematical notation:

$$\theta = \frac{m_{\text{wet}} - m_{\text{dry}}}{\rho_w \cdot V_b} \quad \ldots\ldots\ldots\ldots\text{ eqn ii}$$

Where:

a) M_{wet} is soil sample before drying in the oven

b) $M_{dry}$is soil sample after drying in the oven

c) ρw is water density

d) $V_b$is the volume of soil sample before

The direct method relies on establishing correlations between soil physical and chemical properties and water content. Within this approach, three techniques are employed: chemical titrations, geophysical sensing, and satellite remote sensing.

Chemical titration involves determining moisture loss in soil samples after freeze drying or heating. Satellite remote sensing utilizes microwave radiation to discern variations in dielectric properties between dry and wet soils. Geophysical sensing deploys physical devices inserted into the soil to gauge moisture content, employing techniques such as electrical resistance, electrical conductivity, soil dielectric, soil tension, TDR (Time Domain Reflectometry), FDR (Frequency Domain Reflectometry), soil capacitance, among others.

A controlled irrigation system may feature a control device to assess whether soil requires irrigation and at least one irrigation structure with an actuator regulating water flow. The actuator can be communicatively linked to the control device, delivering water for irrigation. This system may also integrate at least one Time Domain Reflectometry Sensor ("TDRS") in the soil, linked to the control device for soil moisture measurement. Based on data from the TDRS, the control device determines whether to initiate irrigation. Additionally, an irrigation system control method may involve deploying multiple TDRS units with probes, placing each at varying soil depths, measuring soil moisture content, and executing irrigation decisions based on the measurements.

Sensor Installation

A single sensor has the capability to manage irrigation across multiple zones, where each zone is defined by a solenoid valve. Alternatively, individual sensors can be employed for each zone. When using one sensor for multiple zones, it is strategically placed in the zone that typically experiences the driest conditions or requires irrigation the most, ensuring comprehensive and adequate irrigation throughout all zones.

Guidelines for burying soil moisture sensors include:

i. Positioning sensors in the root zone of the plants to be irrigated, as this is where water extraction occurs. For turf grass, burying the sensor at approximately three inches deep is recommended to ensure satisfactory turf or landscape quality.

ii. Ensuring that sensors are in close contact with the soil after burial, with no air gaps around the sensor. The soil should be packed firmly around the sensor.

iii. If a single sensor is used to control the whole irrigation system, it should be inserted in the zone requiring water first to guarantee adequate irrigation for all zones, typically an area with the most sun exposure.

iv. Placing sensors at least 5 feet away from the houses or impervious surfaces (such as driveways), and maintaining a distance of 3 feet from planted bed areas.

v. Locating sensors at least 5 feet away from irrigation heads and towards the center of an irrigation zone.

vi. Avoiding burial of sensors in high-traffic areas to prevent excessive soil compaction around the sensor.

3.3.4 WATER PUMP

A water pump as shown figure 3.5 serves the purpose of supplying water artificially for specific tasks and can be electronically managed by interfacing it with a microcontroller. Activation and deactivation of the water pump can be achieved by transmitting signals as needed. This artificial water supply process is commonly referred to as pumping. Various types of water pumps exist for diverse applications. In this project, a small water pump is utilized, and it is connected to an H-Bridge.

Figure 3.5: Water Pump

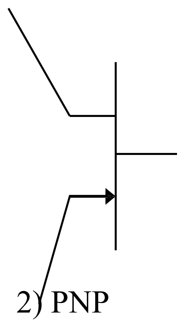
Pumping water is a fundamental and efficient method, surpassing the practicality of manual methods like using hands or lifting it in a handheld bucket. This holds true whether the water is sourced from a freshwater supply, transported to a specific location, purified, or utilized for purposes such as irrigation, washing, sewage treatment, or removing water from an undesirable area. Irrespective of the purpose, the energy needed for water pumping is a highly demanding aspect of water consumption. All alternative processes rely on either water descending from a higher point or a pressurized plumbing system for their operation.

3.3.5 TRANSISTOR

A transistor is a semiconductor device used for amplifying and switching electronic signals and electrical power. It represents a modern, miniature semiconductor equivalent of the vacuum tube, and it was invented in 1947 by Bardeen in the United States. Transistors are packaged as individual discrete components. There are two main types of transistors: the bipolar junction transistor (BJT) and the Field Effect transistor (FET).

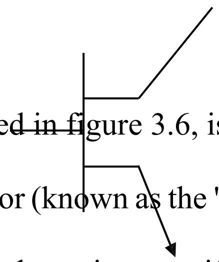
Consisting of semiconductor material with at least three terminals for connection to an external circuit, applying voltage or current to one pair of the transistor's terminals alters the current flowing through another pair of terminals. This property allows a transistor to effectively amplify a signal, as the controlled (output) power can exceed the controlling (input) power.

In the context of the project being studied, the transistor type used belongs to the category of the bipolar junction transistor. The bipolar transistor is composed of three layers of semiconductor material sandwiched together, known as the base, collector, and emitter. This structure makes it a three-terminal device. The bipolar junction transistor (BJT) can be further classified into:



1) NPN 2) PNP

Figure 3.6: (1) NPN and (2) PNP



NPN, depicted in figure 3.6, is one of the bipolar transistor types, featuring a layer of P-doped semiconductor (known as the "base") sandwiched between two N-doped layers. A small current entering the base is magnified to generate a significant collector and emitter current. Specifically, when a positive potential difference is observed from the emitter of an NPN transistor to its base (i.e., when the base is at a higher potential relative to the emitter) and a positive potential difference is measured from the base to the collector, the transistor becomes active. In this "on" state, current flows between the collector and emitter. The majority of this current is carried by electrons moving from the emitter to the collector as minority carriers in the P-type base region. To enable higher current and faster operation, most contemporary bipolar transistors utilize the NPN configuration, as electron mobility is greater than hole mobility.

The transistor utilized is the C945, which amplifies electrical signals for the purpose of switching the relay device. Its maximum current, IC, is 500mA.

3.3.6 SILICON DIODE

A diode as shown in figure 3.8 is a two-terminal, active, non-linear device employed to regulate voltage and current within a circuit. It allows current to flow in a single direction, exhibiting forward current bias when the applied voltage to the diode is positive relative to the cathode. In the forward-biased direction, the effective resistance across the diode is minimal. Conversely, when reverse-biased, the diode functions as an efficient conductor for forward current and an effective insulator for reverse current.

To accommodate such currents, a substantial junction area is necessary to keep the forward resistance of the diode at a minimum. However, even with this design, the diode may generate heat. The black resin case aids in dissipating this heat.

In the opposite direction (when the diode is "off"), it's crucial for the resistance to current flow to be high, and the insulation provided by the depletion layer between the P and N layers must be highly effective to prevent "reverse breakdown," a situation where the diode's insulation fails due to the high reverse voltage across the junction.

Silicon diodes are available in various configurations with different characteristics. They vary in their capacity to carry current, ranging from milliamps to tens of amps. Some have reverse breakdown voltages in the thousands, while others utilize their junction capacitance for tuning purposes in radio and TV tuners. A wide range of diode types can be explored in suppliers' catalogs.

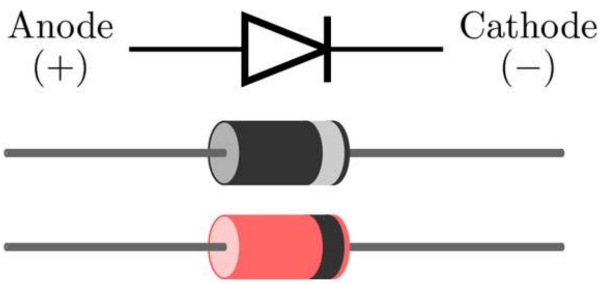


Figure 3.7: Diode

3.3.7 RESISTOR

A resistor is a device meticulously crafted to possess a precise level of resistance against the flow of current. Employed in circuits, the resistor serves to regulate current, induce a voltage drop, or perform related functions, such as limiting the current passing through components like liquid crystal displays (LCDs), transistors, and diodes. The specific value of each resistor dictates the current traversing through it, and this value is discernible through the colour bands present on the resistor. The resistance of a resistor constitutes a fundamental property, as illustrated by the equation:

$$R=IV \text{……. eqn i}$$

Where:

- R denotes the resistance of the resistor,
- V denotes the voltage across the resistor, and
- I denote the current flowing through the resistor.

Resistors can be interconnected in either series or parallel configurations, depending on the requirements of the circuit. The unit of measurement for resistance is expressed in Ohms (Ω).

Resistor in Series

The resistors are joined end-on-end as shown below. It can be proved that the equivalent resistance or total resistance between points X and Z is equal to the sum of the three individual resistances.

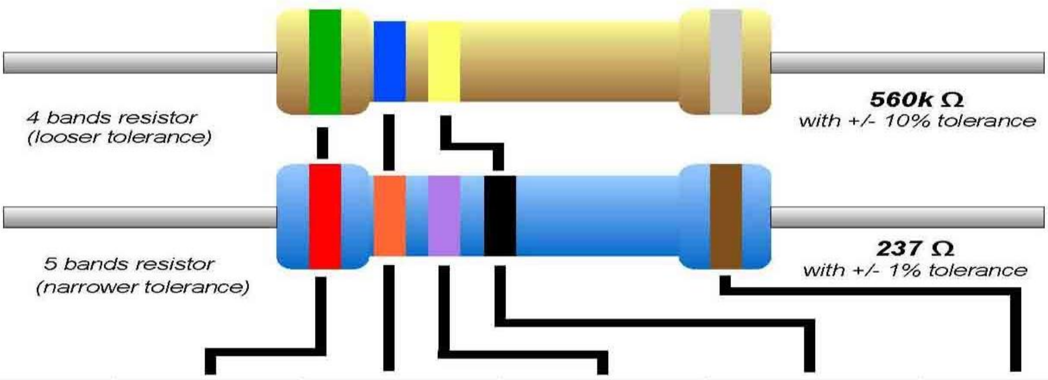
RT = R1 + R2 + R3 + ……… eqn ii

Resistor in Parallel

They are joined in parallel, in this case the potential difference across one resistance is the same and the current in each resistor is different and is given by ohm's law

I/RT = I/R1 + I/R2 + I/R3 + …… eqn iii

Resistor Colour Code



Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	x 1 Ω	
Brown	1	1	1	x 10 Ω	+/- 1%
Red	2	2	2	x 100 Ω	+/- 2%
Orange	3	3	3	x 1K Ω	
Yellow	4	4	4	x 10K Ω	
Green	5	5	5	x 100K Ω	+/- .5%
Blue	6	6	6	x 1M Ω	+/- .25%
Violet	7	7	7	x 10M Ω	+/- .1%
Grey	8	8	8		+/- .05%
White	9	9	9		
Gold				x .1 Ω	+/- 5%
Silver				x .01 Ω	+/- 10%

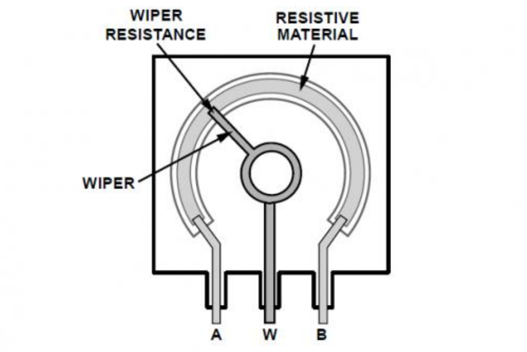
Figure 3.8: Resistor Colour Code

Tolerance codes on 5-band resistors exclusively utilize the colors brown, red, green, blue, and violet as shown figure 3.9. Every 5-band resistor incorporates a colored tolerance band. In contrast, the blank (20%) "band" finds application solely in the "4-band" code, which consists of three colored bands plus a blank "band."

3.3.8 POTENTIOMETER

A potentiometer as shown in figure 3.10, commonly referred to as a pot, is a resistor with three terminals featuring a sliding or rotating contact, creating a customizable voltage divider. When utilizing only two terminals – one end and the wiper – it is use as a variable resistor or rheostat.

(a) External View



(b) Internal View

Figure 3.9: Potentiometer

3.3.9 CAPACITOR

A capacitor fundamentally comprises two conducting surfaces separated by a layer of insulating medium known as dielectric as shown in figure 3.11. These conducting surfaces are in the form of circular (or rectangular) plates or have a spherical or cylindrical configuration. The main function of a capacitor is to store electrical energy through electrostatic stress in the dielectric. The plates of the capacitor maintain different potentials, and this property is referred to as the capacitance of the capacitor. The unit of capacitance is expressed in farads (F), defined as the capacitance of a capacitor between its plates when a potential difference of 1 volt appears across it upon charging with 1 coulomb of electricity.

Charge (coulombs) = capacitance (farads) …… eqn i
Applied p.d (volts)

Or symbol Q/V = C ….. eqn ii

Therefore Q = CV (coulombs) … eqn iii

Capacitors can be connected in parallel or in series. The resultant of capacitance of capacitors in parallel is the arithmetic sum of their respective capacitances.

CT = C1 + C2 + C3 +………. eqn iv

While the reciprocal of the resultant capacitance of capacitors connected in series is the reciprocal of their respective capacitance.

I/CT = I/C1 + I/C2 + I/C3 ….. eqn v

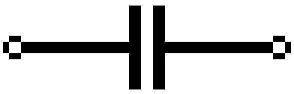
Factors that affect the value of a capacitor depend primarily on:

i. Area of plates

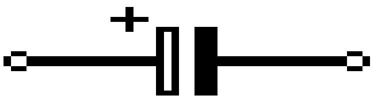
ii. Separation distance between plates and

iii. The dielectric constant of the dielectric material between the plates.

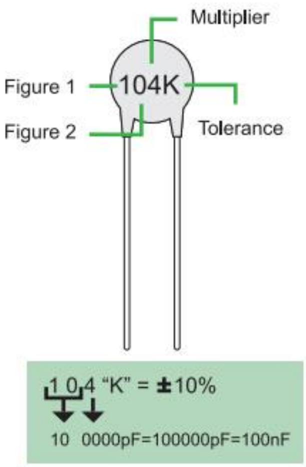
Capacitor Symbols



Capacitor



Polarized Capacitor



Ceramic Capacitor

VALUE (F1 & 2)	MULTIPLIER	LETTER	TOLERANCE
0	1	B	± 0.1pF
1	10	C	± 0.25pF
2	10^2	D	± 0.5pF
3	10^3	F	± 1%
4	10^4	G	± 2%
5	10^5	H	± 3%
6	N/A	J	± 5%
7	N/A	K	± 10%
8	0.01	M	± 20%
9	0.1	Z	± 80%/-20%

Figure 3.10: How to find Ceramic Capacitor

Table 3.2: General Table for Capacitor

Multiplier Table (Ceramic)

Number	Multiply By (Additional # of Zeros)
0	None (0)
1	10 (1)
2	100 (2)
3	1,000 (3)
4	10,000 (4)
5	100,000 (5)
6	1,000,000 (6)

Common Temperature Coefficient Codes (Ceramic)

Code	Tolerance
C	±0.25pF
J	±5%
K	±10%
M	±20%
D	±0.5pF
Z	+80% / -20%

Table 3.3: Ceramic Capacitor General Table

Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code	Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code
10	0.01	0.00001	100	4700	4.7	0.0047	472
15	0.015	0.000015	150	5000	5.0	0.005	502
22	0.022	0.000022	220	5600	5.6	0.0056	562
33	0.033	0.000033	330	6800	6.8	0.0068	682
47	0.047	0.000047	470	10000	10	0.01	103
100	0.1	0.0001	101	15000	15	0.015	153
120	0.12	0.00012	121	22000	22	0.022	223
130	0.13	0.00013	131	33000	33	0.033	333
150	0.15	0.00015	151	47000	47	0.047	473
180	0.18	0.00018	181	68000	68	0.068	683
220	0.22	0.00022	221	100000	100	0.1	104
330	0.33	0.00033	331	150000	150	0.15	154
470	0.47	0.00047	471	200000	200	0.2	254
560	0.56	0.00056	561	220000	220	0.22	224
680	0.68	0.00068	681	330000	330	0.33	334
750	0.75	0.00075	751	470000	470	0.47	474
820	0.82	0.00082	821	680000	680	0.68	684
1000	1.0	0.001	102	1000000	1000	1.0	105
1500	1.5	0.0015	152	1500000	1500	1.5	155
2000	2.0	0.002	202	2000000	2000	2.0	205
2200	2.2	0.0022	222	2200000	2200	2.2	225
3300	3.3	0.0033	332	3300000	3300	3.3	335

3.3.10 LCD

The Liquid Crystal Display (LCD) as shown figure 3.12 screen serves as an electronic display module with diverse applications in electronics. Among the commonly utilized LCDs in circuits, the 16x2 display is fundamental. LCDs are a popular choice for displays due to their cost-effectiveness, ease of programming, and capability to showcase a broad spectrum of characters and animations. In the case of a 16x2 LCD, it comprises two display lines, each having the capacity to exhibit 16 characters. This type of LCD is equipped with Command and Data registers, where the command register stores instructions provided to the LCD, and the

Data register stores the information intended for display.

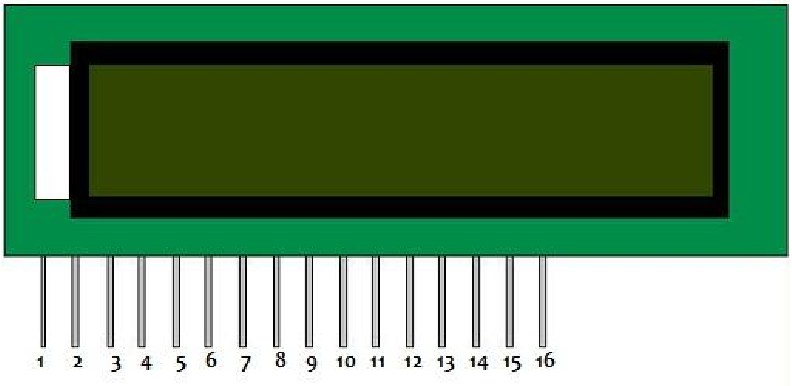


Figure 3.11: LCD (12×2)

In an 8-bit configuration, 8 data pins (DB0-DB7) are employed, whereas in a 4-bit configuration, only 4 data pins (DB4-DB7) are utilized. The pin connections for the LCD are shown in table 3.4 below.

Table 3.4: LCD Pin configuration

Pin number	**Function**	**Symbol**
1	Ground(0V)	VSS
2	Supply voltage (5V)	VDD
3	Contrast adjustment; through a variable resistor (potentiometer)	V0
4	Selects command register when low; and data register	RS
5	Low to write to the register; High to read from the register	RW
6	Sends data to data pins when a high to low pulse is given	E
7	8-bit data pins	D0
8	8-bit data pins	D1
9	8-bit data pins	D2
10	8-bit data pins	D3
11	8-bit data pins	D4
12	8-bit data pins	D5
13	8-bit data pins	D6
14	8-bit data pins	D7

15	Backlight VCC (5V)	A
16	Backlight Ground (0V)	K

3.3.11 RELAY

This device as shown in figure 3.13 is an electromagnetic switch that becomes operational when an electric current is supplied to it. Relays leverage small currents to control substantial currents, typically employing the principles of electromagnetism for their operation. While electromagnetism is the prevailing operating principle for most relays, other principles such as solid-state technology are also employed. A contact relay, for instance, is a type capable of managing the high power needed to directly control an electric motor or other significant loads. In contrast, solid-state relays, devoid of moving parts, utilize semiconductor devices for the switching process.

The relay board is equipped with three pins, designated as normally open (NO), normally closed (NC), and common (C). When the relay is inactive, the common pin is linked to the NC pin; when the relay is activated, it connects to the NO pin. The input pin receives a logic high signal from the Arduino Uno, triggering the relay and establishing a connection between common and NO, powering the device until the relay deactivates. The "VCC" and "GND" pins of the relay are connected to the 5V power supply and ground, respectively.

Figure 3.12: Relay

3.3.12 LED

A light-emitting diode (LED) as shown figure 3.14 is a semiconductor light source with two leads. It functions as a p–n junction diode, emitting light upon activation. Applying an appropriate voltage to the leads allows electrons to recombine with electron holes within the device, releasing energy in the form of photons. This phenomenon, known as electroluminescence, determines the color of the emitted light based on the semiconductor's energy band gap.

Typically small in area (less than 1 mm2), an LED may incorporate integrated optical components to shape its radiation pattern. First introduced as practical electronic components in 1962, early LEDs emitted low-intensity infrared light, commonly used in remote-control circuits. The initial visible light LEDs were limited to low-intensity red emissions. However, modern LEDs span the visible, ultraviolet, and infrared wavelengths, featuring exceptionally high brightness.

Originally employed as indicator lamps in electronic devices, LEDs soon evolved into numeric readouts like seven-segment displays, frequently seen in digital clocks. Ongoing advancements have expanded their usage to environmental and task lighting. LEDs offer numerous advantages over incandescent light sources, including lower energy consumption, extended lifespan, enhanced physical durability, compact size, and rapid switching capabilities.

While LEDs are now utilized in diverse applications such as general lighting, traffic signals, camera flashes, aviation lighting, automotive headlamps, advertising, and lighted wallpaper, till 2016, LEDs potent enough for room lighting remain relatively more expensive. They demand precise current and heat management compared to compact fluorescent lamps with comparable output. Nevertheless, LEDs are considerably more energy-efficient and arguably pose fewer environmental concerns regarding disposal.

Figure 3.13: LED

3.3.13 BOOST CONVERTER

A boost converter as shown in figure 3.15, also known as a step-up converter, is a type of DC-to-DC power converter designed to increase voltage (while decreasing current) from its input (supply) to its output (load). Belonging to the class of switched-mode power supplies (SMPS), it incorporates at least two semiconductors (a diode and a transistor) and a minimum of one energy storage element, such as a capacitor, inductor, or a combination of both. To mitigate voltage ripple, filters comprising capacitors (sometimes in conjunction with inductors) are typically introduced into both the output (load-side filter) and input (supply-side filter) of such a converter.

Figure 3.14: Boost Converter

3.3.14 JUMPER WIRES

A jumper wire as shown in figure 3.16 refers to an electrical wire or a bundle of wires in a cable, equipped with connectors or pins at both ends (and occasionally left "tinned" without connectors). Primarily, these wires are employed to establish connections between components on a breadboard or within prototype or testing circuits, either internally or with other devices or components, all without the necessity for soldering.

The incorporation of jumper wires into circuit board assemblies is an inevitable requirement, categorized as follows:

Jumper wires that are integral components of the original design must have their routing, termination, and bonding documented through engineering instructions or drawing notations.

Those added post-original design to implement changes necessitate documentation via engineering change notice instructions or drawing notations. Additionally, jumper wires can be utilized to rectify defects as needed.

Figure 3.15: Jumper Wires

3.4 CIRCIUT DIAGRAM

The figure 3.17 below shows the complete circuit diagram of the project. Using n Arduino Uno, the sensor, the LCD and the pump are connected to their respective pins as shown in the diagram below.

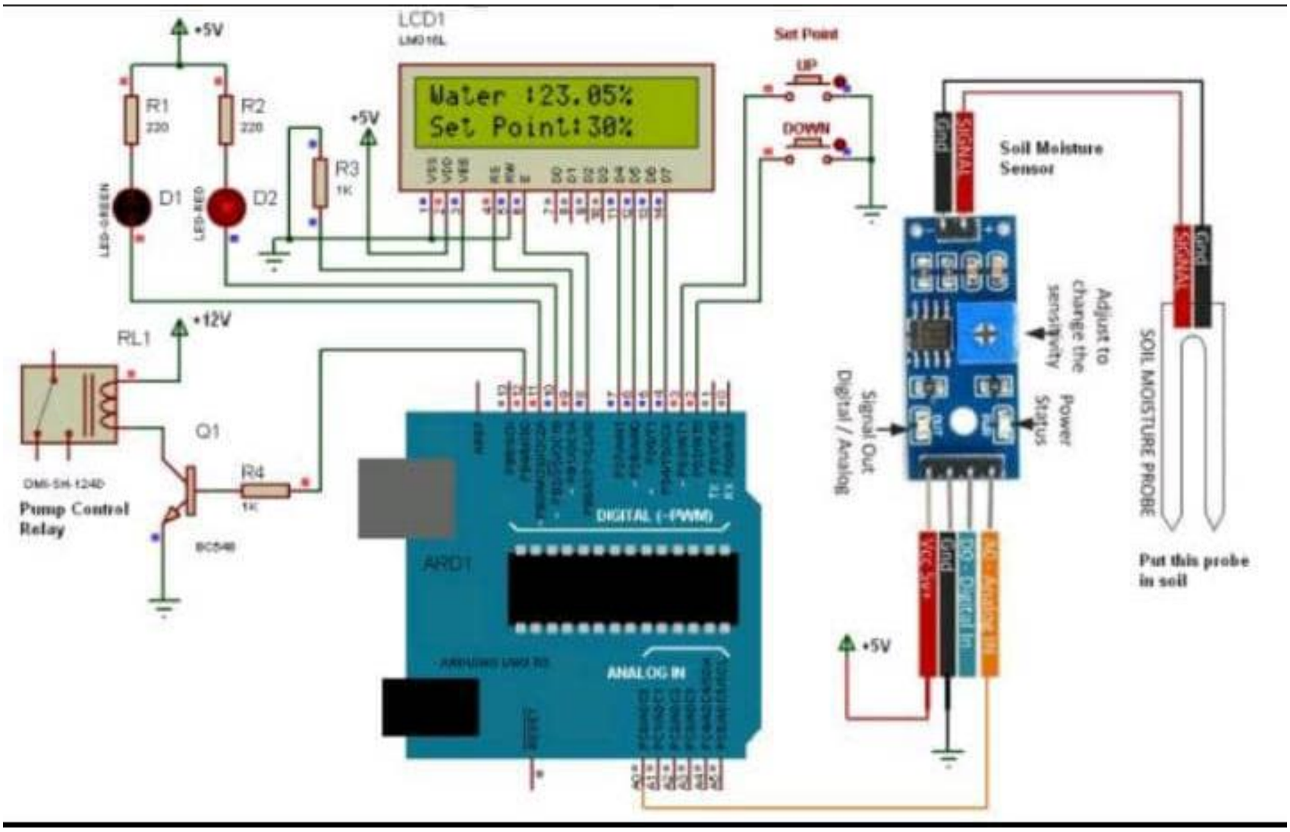


Figure 3.16: Circuit Diagram

3.5 FLOW CHART

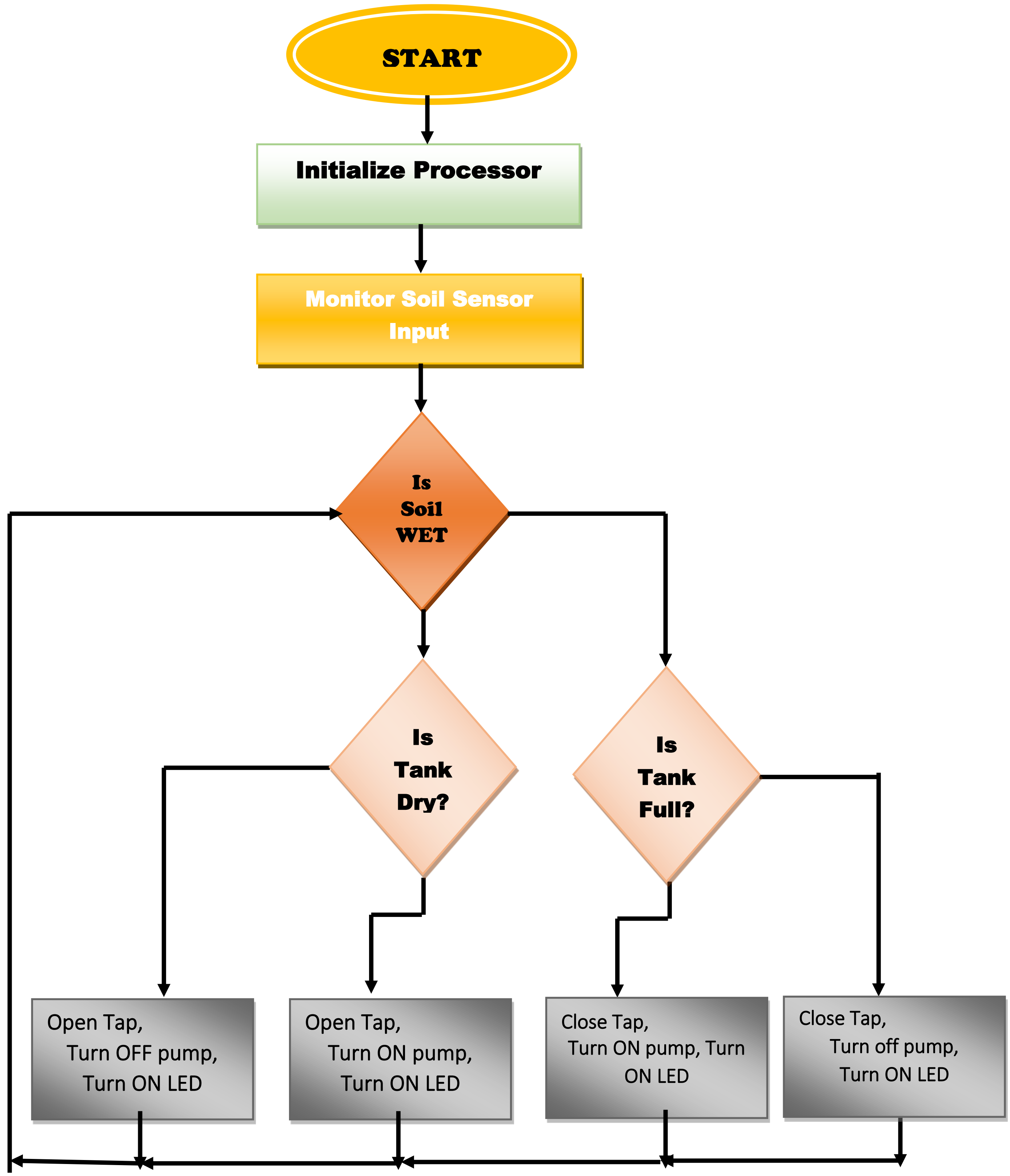


Figure 3.18: Flow chart of Program Executed by Microcontroller

CHAPTER FOUR

4.0 IMPLEMENTATION, TEST AND DISCUSSION OF RESULT

4.1 INTRODUCTION

This chapter outlines the tests conducted on individual sections of the entire system and presents the corresponding results, along with an overview of the overall system's performance. To validate the proper functioning of each component, a meticulous testing process was undertaken. The following tools were employed for effective testing of these diverse components:

- Digital Multimeter
- Vero board/Breadboard
- Sensor Probes
- Soldering Iron & Lead Cable
- Light Emitting Diodes
- Proteus and Multisim LAB simulation software
- Designing the PCB board, mounting the components, and soldering them
- Arduino Uno board
- USB programming cable (A to B)
- Solid wire for connections

Comprehensive testing was conducted on every component and section constituting the circuit to ensure the secure lock's correct and satisfactory operation. The debugging process utilized the Arduino Uno and Proteus LAB simulation software. Each section of the code underwent thorough debugging to guarantee proper functionality through a step debugging approach. This involves utilizing the facility in the Arduino Uno and Proteus LAB simulation software, allowing for stepping into the program while simultaneously observing registers and flag settings.

4.2 PROGRAMMING

The Arduino Uno is programmable through the Arduino IDE software, making it a user-friendly yet powerful single-board computer that has gained significant popularity in both hobbyist and professional circles. Being open-source, the Arduino offers cost-effective hardware and free development software. The Arduino Uno board is equipped with an Atmel ATmega328 microcontroller operating at 5 V, featuring 2 Kb of RAM, 32 Kb of flash memory for program storage, and 1 Kb of EEPROM for parameter storage. With a clock speed of 16 MHz, it can execute approximately 300,000 lines of C source code per second.

The board includes 14 digital I/O pins and 6 analog input pins. It provides a USB connector for communication with the host computer and a DC power jack for an external 6-20 V power source, such as a 9 V battery, when running programs independently. Headers are available for interfacing with I/O pins using 22 g solid wire or header connectors.

The Arduino programming language is a simplified version of C/C++, making it familiar to those with C programming knowledge. For those unfamiliar with C, only a few commands are required for performing useful functions. Notably, you can develop and debug a control program on the host PC, download it to the Arduino, and it will run autonomously. Disconnecting the USB cable does not affect the program's operation, and the last stored program will resume when the battery is reconnected. This allows for program execution without the need for the host PC once development and debugging are complete.

4.3 TESTING THE SYSTEM

4.3.1 TESTING THE LCD

To facilitate the display, a 16x2 Liquid Crystal Display (LCD) was selected. The LCD's D4, D5, D6, and D7 pins were employed as data lines in a 4-bit mode configuration, linked to Arduino pins 5, 4, 3, and 2, respectively. Pin 15 (A) was connected to Vcc, and pin 16 (K) was connected to GND, serving the LEDs integrated into the LCD circuit board as shown in figure 4.1. The LCD's Enable pin (E) found its connection to digital pin 11 on the Arduino board, while the Register Select (RS) pin on the LCD was linked to Arduino digital pin 12. The R/W pin of the LCD was connected to GND (ground). Refer to the diagram below for an illustration of the LCD-microcontroller interface.

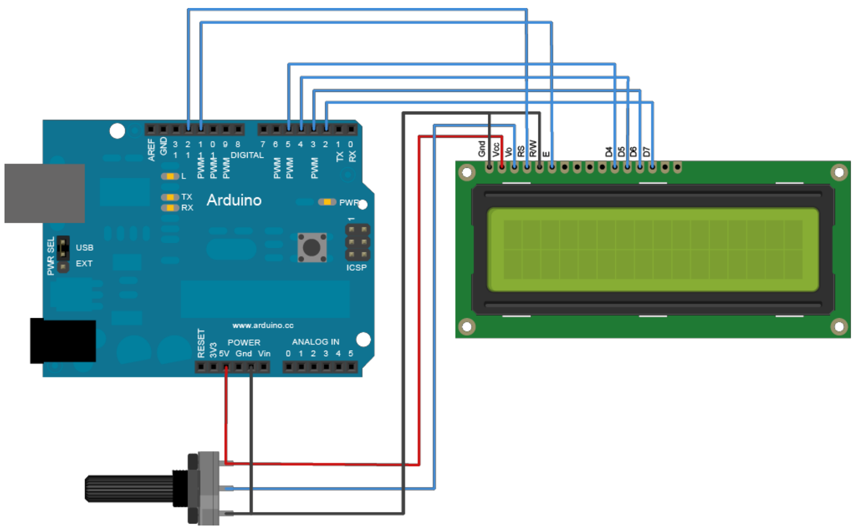


Figure 4.1: LCD Connection to Arduino Board

4.3.2 TESTING THE WATER PUMP

For the final component of the automated irrigation system, an electric motor (240VAC) was chosen to serve as the water pump. The initial two units, namely the sensing unit and the microcontroller-based control unit, operate on 5VDC. To establish a connection between these units, a 5V DC relay (SLT73-5D-1Z) was employed as the isolation unit as shown in figure 4.2. The microcontroller was linked to the relay through an NPN transistor (2N4123), and to safeguard the transistor during activation, a resistor was incorporated. This resistor acts to limit the current flowing through the transistor, employing Ohm's law, similar to the approach applied with LEDs, as illustrated below.

$$R_{min} = \frac{(5-0.7)V}{40mA} = 107.5\Omega \text{ .... eqn i}$$

A resistor of470$\Omega$was selected and thus the current through the transistor was limited to;

$$I = 4.3V / 470\Omega = 9.12\ mA \text{ ..... eqn ii}$$

To keep the microcontroller from back e.m.f during switching a diode was connected across the relay. The connection was as shown below.

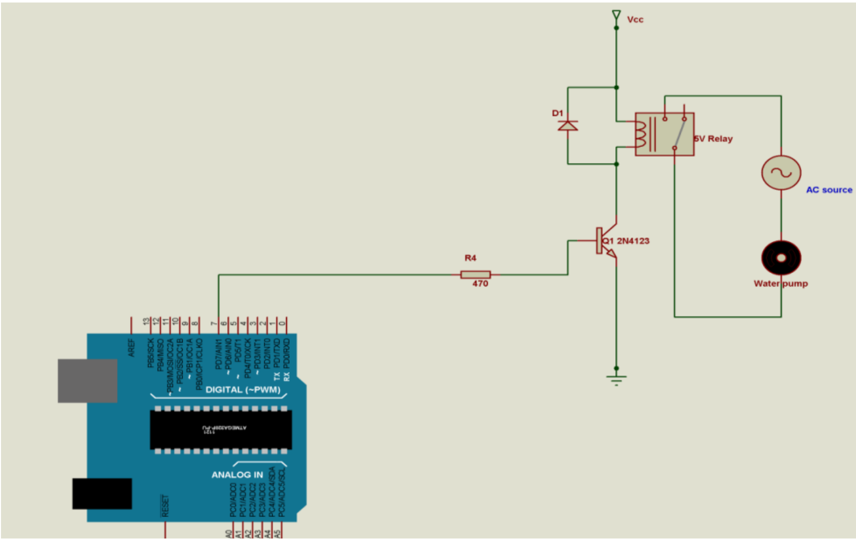


Figure 4.2: Relay interfacing of arduino to the 230VAC pump

4.3.3 TESTING THE SENSOR

The arduino was connected to the soil moisture sensor through a digital PCB interface as shown figure 4.3. This PCB interface is equipped with a digital potentiometer that adjusts the sensor sensitivity when operating in digital mode. The output of the PCB interface comprises four connection pins, as detailed in the table below.

Table 4.1: Sensor pins

Sign	Connect
Vcc	Connected to 5VDC
GND	Connected to ground
A0	Analog value output connector
D0	Digital valueoutputconnector （0 or 1）

The analogue configuration was selected as its more stable compared to the digital configuration. The PCB drive pin A0 was connected to the arduino analog pin A0 as shown in table 4.1.

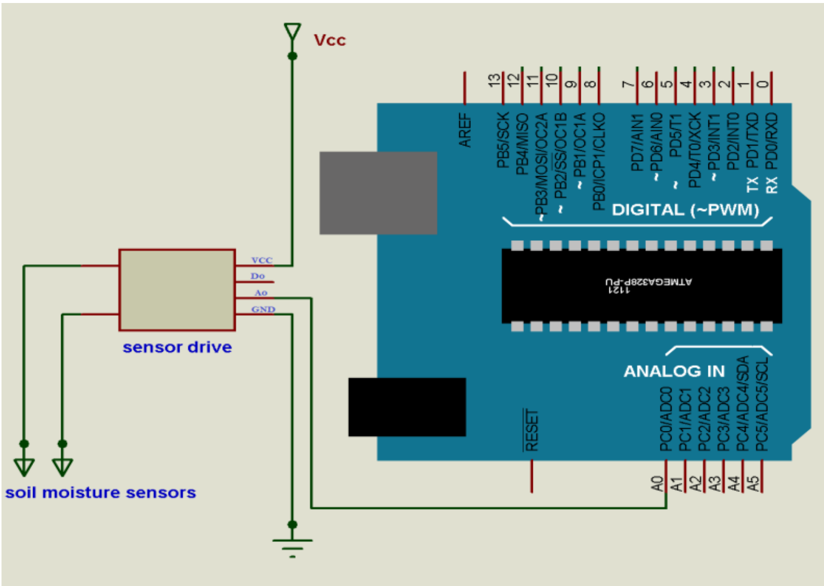


Figure 4.3: Connection of the sensor to arduino board

The resistance was conveyed to the arduino analog pin A0 as the sensor output. The resistance, influencing the current flow between the sensor probes, varies based on both soil moisture levels and soil type. The calculation of the current passing through the sensor probes (Iout) for various soils and different soil moisture levels is demonstrated below:

$$Iout = \frac{Vcc}{\{SoilResistancevalue(R_S)\}} \text{ .... eqn i}$$

4.4 DISCUSSION

In this design, certain benchmark elements have not undergone comprehensive study and testing, primarily due to time constraints. Nevertheless, the following observations have been noted:

i. The installation of the automated irrigation system is notably straightforward, with the layout of the geotextile being the most intricate step. No specialized technicians are necessary, but it is recommended to provide users with an installation manual, a chart detailing the water requirements of common houseplants, and a list of compatible soil types. Setting up the pipe network should also be relatively uncomplicated, with the option of including or recommending a tank and compatible pipe by the manufacturer. More intricate work may be needed for connecting the valve to the water mains.

ii. The overall water savings of the system have not been fully examined. However, the effectiveness of the geotextile and moisture probe has been validated through prior experiments conducted in actual agricultural contexts.

iii. An experiment demonstrated the challenge of maintaining a consistent soil moisture level solely through human feedback. During the limited testing periods, minimal human intervention was required, except for verifying the system's operation and ensuring the water tank, if used, is not empty. However, there is currently no mechanism to alert the user to emergencies such as overflow, an empty tank, or component failure.

iv. Further testing in a real home or greenhouse environment is essential to assess the system's reliability and durability. Extended tests should be conducted to determine the significance of water and labour savings. Additionally, all measurements and tests were conducted on a limited collection of plants of a single species, and different plants with varying water requirements should be considered for a more comprehensive evaluation.

vi. Regular maintenance for the irrigation system is generally unnecessary, except for tasks such as refilling the water tank (if used), cleaning the geotextile, pipes, and valve, and replacing broken parts. Most replacement components can be readily found in electronic shops or hardware stores.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

The system serves as an insurance mechanism for both crops and gardens, safeguarding them against severe weather conditions such as unexpected rain, hailstones, and temperature fluctuations. This protection ensures optimal cultivation for farmers. Additionally, the system facilitates efficient water usage by addressing variations in soil moisture levels among different crops through the integration of a soil moisture sensor. The system works entirely by rechargeable batteries.

5.2 SUMMARY

The fundamental idea behind a soil moisture sensor system involves placing a sensor in a representative section of the lawn to determine if the soil has adequate moisture for the grass. If sufficient moisture is detected, the sensor prevents the activation of the sprinkler system, avoiding unnecessary water application. Conversely, if the sensor senses dry soil, it allows irrigation to occur. The following information aims to simplify the understanding of the various types of soil moisture sensors and their functioning.

The Microcontroller-based irrigation system effectively monitors and manages all activities of the drip irrigation system. It measures soil moisture and surrounding temperature, adjusting water supply to the crop accordingly to prevent waterlogging. This system saves water by delivering it directly to the roots, enhancing crop quality. It also saves time, eliminates human errors in adjusting soil moisture levels, and maximizes net profits.

5.3 CONCLUSION

The "AUTOMATIC IRRIGATION SYSTEM USING MICROCONTROLLER" has been successfully designed and tested, integrating all hardware components. Each module's presence has been carefully justified, contributing to the optimal performance of the unit. The system functions automatically, with moisture sensors measuring the water content of various plants. If the moisture level falls below the desired threshold, the sensor signals the IC (Microcontroller), activating the Water Pump to supply water to the respective plant via the hose. Once the moisture level is attained, the system automatically stops, turning off the Water Pump. Thorough testing has confirmed the functionality of the entire system, affirming its successful operation.

5.4 RECOMMENDATION

To enhance the effectiveness and efficiency of the system, the following recommendations can be considered:

i. Implement cost-effective techniques to address the limitation of requiring soil-specific calibration.

ii. A successfully designed and assembled automated irrigation system aims to reduce water consumption, human monitoring time, and labor associated with traditional methods.

iii. Integrate technology to trigger an LED and alarm indicating "Empty" when the water tank and reservoir are depleted, providing status information about the pump.

iv. Provide the option for the system to be controlled either automatically or manually.

v. Enhance the system by integrating temperature and humidity sensors to monitor farm weather conditions.

vi. Utilize a timed feedback control in the design to measure soil moisture and activate the valve on demand at regular intervals.

vii. Manufacture the system at relatively cost effective using simple electronic parts; note that the soil moisture probe is the most costly component.

viii. Ensure easy installation in a home environment with minimal resource requirements.

viii. Acknowledge that the design is still in the prototype stage; additional tests are needed to demonstrate efficiency, durability, and reliability. Furthermore, consider making improvements to enhance the system's versatility, customization, and user-friendliness.

5.5 BILL OF MATERIALS

The table below shows the materials used quantities, rates and total amount.

Table 5.1 bill of materials

S/N	COMPONENTS	QUANTITY	RATE (₦)	AMOUNT (₦)
1	Arduino UNO	1	10000	10000
2	Bread board	1	1000	1000
3	Dot board	1	400	400
4	Moisture Sensor	1	2500	2500
5	Water Pump	1	1200	1200
6	Lithium Battery	2	1440	3360
7	Potentiometer	1	100	100
8	Capacitor	1	840	840
9	Transistor	1	400	400
10	LED	2	20	40
11	LCD with I2C module	1	9000	9000

12	Resistor	3	20	60
13	Jumper wires(Male-Male and Female-Male)	2	900	1800
14	Soldering led	1	600	600
15	Enclosure	1	3000	3000
16	Boost Converter	2	1400	2800
17	Relay	2	360	720
	TOTAL AMOUNT			**37820**

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APPENDIX 1

SOURCE CODE

```
#include<LiquidCrystal.h>
#include <SoftwareSerial.h>
// LCD CONNECT    (RS, E, D4, D5, D6, D7) AND RW, D3-D0 CONECT TO    GND
LiquidCrystal  lcd(11, 10, 8, 7, 6,  5);
  const int PUMP = 13;
  const int VALVE = 12;
  int alarm = 1;
//ECHO AND TRIGGER PINS
const int reserviorPin= A0;
const int moisturePin= A3;
const int overheadPin = A5;
//INITIAL SETUPS
void setup()
{
pinMode(alarm, OUTPUT);
```

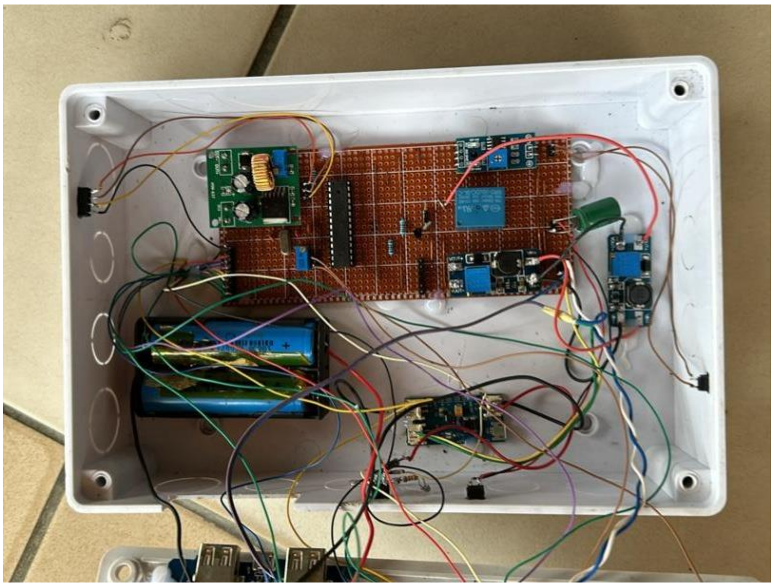
```
pinMode(VALVE, OUTPUT); // SET VALVE PIN AS OUTPUT
pinMode(PUMP, OUTPUT); // SET PUMP PIN AS OUTPUT
digitalWrite(alarm, LOW);
digitalWrite(VALVE, LOW);
digitalWrite(PUMP, LOW);
lcd.begin(16, 2);     // 16X2 LCD TYPE
lcd.clear();          // CLEAR ALL LCD CONTENT
}
void loop() {
 float  moisture =  analogRead(moisturePin);
  float moistureLevel = (300*moisture)/1024;
  float  overhead =  analogRead(overheadPin);
  float overheadLevel = (300*overhead)/1024;
  float  reservior =  analogRead(reserviorPin);
  float reserviorLevel = (300*reservior)/1024;
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Moist.=");
lcd.print(moistureLevel,0);
lcd.print("% ");
lcd.setCursor(0,1);
lcd.print("Res=");
lcd.print(reserviorLevel,0);
lcd.print("% ");
lcd.print("Tnk=");
lcd.print(overheadLevel,0);
lcd.print("% ");
delay(1000);
 //all low
    if  (moistureLevel <= 20 && overheadLevel >=30){
  digitalWrite(VALVE, HIGH);
  delay(10);   // wait for a second
```

```
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Low Moisture");
lcd.setCursor(0,1);
lcd.print("VALVE is ON");
delay(1000);
  }
  if  (moistureLevel >= 100){
  digitalWrite(VALVE, LOW);
  delay(50);
  }
 if  (reserviorLevel >= 30 && overheadLevel <=20){
  digitalWrite(PUMP, HIGH);
  delay(10);   // wait for a second
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Low Overhead");
lcd.setCursor(0,1);
lcd.print("PUMP is ON");
delay(1000);
  }
 if  (reserviorLevel <= 30 && overheadLevel <=20){
  digitalWrite(PUMP, LOW);
   digitalWrite(alarm, HIGH);
  delay(10);   // wait for a second
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Low Reservior");
lcd.setCursor(0,1);
lcd.print("Alarm is ON");
delay(500);
```

```
digitalWrite(alarm, LOW);
delay(500);
  }
  if  (overheadLevel >= 100){
  digitalWrite(PUMP, LOW);
  delay(50);
  }
  if  (reserviorLevel >= 50){
  digitalWrite(alarm, LOW);
  delay(50)
    }
  }
```

APPENDIX 2

External View of the System



Internal View of the System