SMART IRRIGATION SYSTEM

The project report submitted to

Veermata Jijabai Technological Institute, Mumbai

For the award of

DIPLOMA IN ELECTRONICS ENGINEERING

Ms. Tejasvi Bansode	(174131006)
Ms. Smruti Pawaskar	(174131009)
Ms. Prajakta Bamankar	(174131017)
Ms. Shrutika Avhad	(174131018)
Ms. Sayali Thite	(174131020)
Ms. Sai Karyekar	(174131022)

Department of Electrical Engineering

Veermata Jijabai Technological Institute, Mumbai

Maharashtra, India

Academic year 2019-20

Smart Irrigation System

The project report submitted to

Veermata Jijabai Technological Institute, Mumbai

For the award of

DIPLOMA IN ELECTRONICS ENGINEERING

By

Ms. Tejasvi Bansode	(174131006)
Ms. Smruti Pawaskar	(174131009)
Ms. Prajakta Bamankar	(174131017)
Ms. Shrutika Avhad	(174131018)
Ms. Sayali Thite	(174131020)
Ms. Sai Karyekar	(174131022)

Under the guidance of

Dr. Rahul Ingle

Department of Electrical Engineering

Veermata Jijabai Technological Institute, Mumbai

Maharashtra, India

Academic year 2019-20

Veermata Jijabai Technological Institute, Mumbai

Department of Electrical Engineering

Approval of the Guide and the External Examiner

Certified on___________________, that the Project titled "SMART IRRIGATION SYSTEM" submitted by following project group:

1) Ms. Tejasvi Bansode
2) Ms. Smruti Pawaskar
3) Ms. Prajakta Bamankar
4) Ms. Shrutika Avhad
5) Ms. Sayali Thite
6) Ms. Sai Karyekar

to the Veermata Jijabai Technological Institute, Mumbai, for the award of DIPLOMA IN ELECTRONICS ENGINEERING and that the students have successfully examine in the viva voce examination held today.

Signature:

Guide:

Affiliation: Dept of Electrical Engg, Veermata Jijabai Technological Institute, Mumbai, Maharashtra, India

Signature:

External Examiner :

Affiliation :

ACKNOWLEDGEMENT

The success and final outcome of this project required a lot of guidance and assistance from many people and we are extremely privileged to have got this all along the completion of the project. All that we have done is only due to such supervision and assistance and we shall not forget to thank them.

This project was possible only with the inspiration and timely guidance of our project guide Dr. Rahul Ingle (Electronics Department, VJTI) who was always available to help and answer us at any time and provided us with all the necessary information for developing a good project. We heartily thank the Head of Department (Electronics engineering), Prof.Vikram Kehri, for his guidance and suggestions during this project work.

We are thankful to and fortunate enough to get constant encouragement, support and guidance from all teaching staff of Electronics and Electrical department who helped us in successfully completing our project work. Also, we would like to extend our sincere esteems to all staff in laboratory for their timely support.

Lastly, we would like to thank our classmates for the encouragement and help without whom this project would not have been possible.

Thank you again!

1) Ms. Tejasvi Bansode

2) Ms. Smruti Pawaskar

3) Ms. Prajakta Bamankar

4) Ms. Shrutika Avhad

5) Ms. Sayali Thite

6) Ms. Sai Karyekar

Department of Electrical Engineering, Veermata Jijabai Technological Institute, Mumbai

DECLARATION

We certify that,

- The work contained in this report is original and has been done by me under the guidance of my guide.
- The work has not been submitted to any other Institute for the award of any diploma, or certificate.
- We have followed the guidelines of the Institute in preparing the thesis.
- Whenever we have used materials (data, theoretical analyses, figures, text, etc.) from other sources, we have given due credit to them by citing them in the text of the thesis and giving their details in the references. necessary.

Sr No	Name of student	Signature
1	Ms. Tejasvi Bansode	
2	Ms. Smruti Pawaskar	
3	Ms. Prajakta Bamankar	
4	Ms. Shrutika Avhad	
5	Ms. Sayali Thite	
6	Ms. Sai Karyekar	

Contents

List of Figures:

List of Tables:

List of Abbreviations:

APEJ	Asia Pacific Excluding Japan
API	Application Program Interface
AREF	Analog Reference
ARM	Advanced RISC Machine
ASCII	American Standard Code for Information Interchange
AVR	Automatic Voltage Regulator
COM	Common
DC	Direct Current
DTMF	Dual Tone Multi Frequency Tuning
EEPROM	Electrically Erasable Programable Read Only Memory
GND	Ground
GPIO	General Purpose Input/output
GUI	Graphical User Interface
HTTP	Hyper Text Transfer Protocol
IDE	Integrated Development Environment

IOREF	Input-Output Reference pin
iOS	iPhone Operating System
IoT	Internet of Things
Kb	Kilobyte
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MATLAB	Matrix Laboratory
MCU	Microcontroller Unit
MEA	Middle East Africa
MHz	Mega Hertz
MISO	Master In Slave Out
MIT	Massachusetts Institute of Technology
MOSI	Master Out Slave In
MQTT	Message Queuing Telemetry Transport
NC	Normally Closed
NO	Normally Open
OS	Operating System
PCB	Printed Circuit Board
PIC	Peripheral Interface Controller
PWM	Pulse Width Modulation
RX	Receiver
SCK	Serial Clock

SCL	Serial Clock
SDA	Serial Data
SDK	Software Development Kit
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
SS	Slave Select
TNG	The Next Generation
TTL	Transistor-Transistor Logic
TWI	Two Wire Interface
TX	Transmitter
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
VCC	Voltage at Common Collector
Vin	Voltage In

CHAPTER 1: INTRODUCTION

1.1 Objective and Aim

The key objective of the project is to monitor the soil's moisture content with the aid of a moisture sensor circuit, and irrigate it based on its nature using a Arduino UNO, NodeMCU, YL-69 and an automatic water inlet setup which can also monitor and record soil moisture which is constantly modified using mobile application and can be controlled in future to optimize these resources so that the plant growth and yield is maximized. A record of soil moisture in ThingSpeak database for backup. This backup directs the farmers regarding the type of crop to be cultivated in future. IoT gives the whole information to the operator about the irrigation. In this project, we experiment for different soils suitable for different crops in various climatic parameters that govern plant growth and allow information to be collected with less labour requirements.

Our aim is to develop a wireless level controlled smart irrigation system to provide irrigation system which is automatic for the plants which help in saving water and money. The main objective is to apply the system for improvement of health of the soil and hence the plant via multiple sensors. In order to replace expensive controllers in current available systems, the Arduino Uno will be used in this project as it is an affordable microcontroller. The Arduino Uno can be programmed to analyse some signals from sensors such as moisture, temperature, and rain. A pump is used to pump the fertilizer and water into the irrigation system. The use of easily available components reduces the manufacturing and maintenance costs. This makes the proposed system to be an economical, appropriate and a low maintenance solution for applications, especially in rural areas and for small scale agriculturists. Bulk of the existing systems employ microprocessor-based systems. These systems offer several technological advantages but are unaffordable, bulky, difficult to maintain and less accepted by the technologically unskilled workers in the rural scenario. The Internet of Things (IoT) is transforming the agriculture industry and enabling farmers to contend with the enormous challenges they face.

1.2 Motivation

Appropriate soil water level is a necessary pre-requisite for optimum plant growth. Also, water being an essential element for life sustenance, there is the necessity to avoid its undue usage. Irrigation is a dominant consumer of water. This calls for the need to regulate water supply for irrigation purposes. Fields should neither be over-irrigated nor under-irrigated. The objective of this project is to design a simple, easy to install methodology to monitor and indicate the level of soil moisture that is continuously controlled in order to achieve maximum plant growth and simultaneously optimize the available irrigation resources on monitoring software ThingSpeak and the sensor data can be seen on Internet.

This research work enhanced to help the small-scale cultivators and will increase the yield of the crops which will inherently increase government economy. Over time, systems have been implemented towards realizing this objective of which automated processes are the most popular as they allow information to be collected at high frequency with less labour requirements.

The industry must overcome increasing water shortages, limited availability of lands, difficult to manage costs, while meeting the increasing consumption needs of a global population that is expected to grow upto 70% by 2050. India's major supply of financial gain is from agriculture sector and seventieth of farmers and general folks rely upon the agriculture. In Republic of India most of the irrigation systems square measure are operated manually. These antique techniques square measure replaced with semi-automated and automatic techniques. The on the market ancient techniques square measure like ditch irrigation, terraced irrigation, drip irrigation system. The global irrigation situation is classified by redoubled demand for higher agricultural productivity, poor performance and decreased accessibility of water for agriculture. These issues are befittingly corrected if we have a tendency to use machine-controlled system for irrigation. Automating farm or nursery irrigation permits farmers to use the correct quantity of water at the correct time, regardless of the provision of labour to show valves on and off. Additionally, farmer's mistreatment automation instrumentation is able to scale back runoff from over watering saturated soils, avoid irrigating at the incorrect time of day, which will improve crop performance by making certain adequate water and nutrients once required. Those valves are also simply automated by mistreatment controllers. They lack in an exceedingly featured mobile application developed for users with acceptable user interface. It solely permits the user to observe and maintain the wetness level remotely in no matter of time. From the purpose of reading and performing at remote places the developed microcontroller primarily based irrigation system will.

CHAPTER 2: LITERATURE SURVEY

The exact primitive methods used to measure moisture of the agricultural field has been analysed in this section to make the suitable modifications and necessary improvisations to automate the process.

2.1 Problems that are faced today:

Today the technology in this particular issue is still hindered.

- In our Agriculture sector, the availability of water is decreasing day by day due to the increase in population, industrialization and short rainfall.
- Wastage of water is caused due to seepage in the drain.
- Increase labour and electricity cost.
- Promote soil erosion**.**

2.2 Primitive methods:

Disadvantages of Traditional Irrigation Methods [1]:

(i) Check Basin Method

- Machines cannot be used in this method because during spray of insecticides or fertilizers, the earthen walls of basins are damaged.
- There is imbalance in distribution of labour. After growth of crops, water reaches the basins in disproportionate quantity thereby causing wastage of water.

(ii) Furrow Irrigation Method

- Due to imbalance in flow of water, wastage of water is caused in it.
- Making 'Dol' for drains requires more labour information.

(iii) Strip Irrigation Method

- It is not suitable for all types of crops.
- It is not possible to get balanced supply of water.

(iv) Basin Irrigation Method

- It is not useful for all crops.

- Wastage of water is caused in it.

Modern Irrigation Methods [2]:

(v) Sprinkler Irrigation Method

- Sprinkler irrigation method is expensive.
- Sprinkler irrigation method cannot be used in all crops.

(vi) Drip Irrigation Method

- Drip irrigation method is expensive.
- In heavy soils, it creates problems of flow and water blockages.

(vii) Pot Irrigation Method

- Irrigation in this method is possible in a limited area.
- It is costly to draw out pitchers again and again and re-fix them.

The table below gives some idea about the different seasonal water needs of the most important field crops [3].

Crop	Crop water requirement (mm/total growing period)
Alfalfa	800-1600
Banana	1200-2200
Barley/Oats/Wheat	450-650
Bean	300-500
Cabbage	350-500
Citrus	900-1200
Cotton	700-1300
Maize	500-800
Melon	400-600
Onion	350-550
Peanut	500-700

Pea	350-500
Pepper	600-900
Potato	500-700
Rice (paddy)	450-700
Sorghum/Millet	450-650
Soybean	450-700
Sugar beet	550-750
Sugarcane	1500-2500
Sunflower	600-1000
Tomato	400-800

Table 1: Crop water requirement

Deficient	When an essential element is at a low concentration that severely limits yield and produces more or less distinct deficiency symptoms. Extreme deficiencies will lead to death of the plant.
Insufficient	When the level of an essential plant nutrient is below that required for optimum yields or when there is an imbalance with another nutrient. Symptoms of this condition are seldom evident.
Sufficient	When the concentration of an essential nutrient is present in adequate amounts for optimum crop growth.
Excessive	When the concentration of an essential plant nutrient is sufficiently high to result in a corresponding shortage of another nutrient.
Toxic	When the concentration of either essential or other elements is sufficiently high to reduce plant growth severely. Severe toxicity will result in death of plants.

Table 2: Water Level specifications

2.3 Research Paper Review

From this research, we can see that there are a few factors that need to be control in the environment. The factor that is to be considered is soil moisture.

M.Nesa Sudha et al., 2011 [4] proposed a TDMA based MAC protocol used to collect data such as soil moisture and temperature for optimum irrigation and to save energy. MAC protocol plays an important role to reduce energy consumption. Two methods used for energy efficiency are Direct Communication method and aggregation method. Direct Communication method provides collision free transmission of data, because all the sensor nodes send data directly to the base station without the need of header node. This method is better where the base station is near but it is not optimum where the base station is far because sensor nodes consume more energy during transmission of data and if there is a lot of data sent to the sensor node so the sensor node is quickly damaged.

Man Zhang et al., 2012 [5] analysed the temporal and spatial variability of soil moisture for the realization of variable irrigation and for improvement of yield in the farm. Temporal variability adopts the changes of soil moisture at the place where the sensor node is installed and analyses soil moisture variation at different times according to the season. Spatial variability analyses and calculates all parameters of soil moisture as average, maximum and minimum in the whole area. The temporal variability curve was drawn according to measure data. It showed that the corn was in severe water stress state during the complete monitoring period.

Sherine M.Abd El-kader et al., 2013 [6] proposed APTEEN (Periodic Threshold sensitive Energy-Efficient sensor Network) protocol. APTEEN is a Hierarchical based routing protocol in which nodes are grouped into clusters. Each cluster has a head node and the head node is responsible for broadcasting data to the base station. APTEEN broadcasts parameter's attribute, which is a set of physical parameters, in which the user is interested to obtain information, Thresholds value i.e. Hard Threshold and Soft Threshold, Schedules as TDMA schedule assigns slots to save energy, which provide collision free transmission.

B. Balaji Bhan et al., 2014 [7] proposed a system to develop WSN based soil moisture controllers that determine the water requirement by comparing soil moisture with predefined threshold value. An intelligent remote system consists of wireless sensor nodes and computer system in which data is transmitted to a server system from where the data accessed by individuals for decision making for automated control of irrigation for the yield productivity.

Sbrine Khriji et al., 2014 [8] describe different type of sensor nodes for real monitoring and control of irrigation system. Each node consists of TelosB mote and actuator. TelosB mote is an ultra-low power wireless module for monitoring applications. Soil nodes used to measure the soil moisture weather nodes used to measure environmental parameter and actuator used for controlling the opening of valves for irrigation. The system was cost efficient and reduced the power consumption.

Yunseop Kim et al., 2008 [9] represented a real time monitoring and control of variable rate irrigation controller. The sensor nodes measure environmental parameter and transmit data to base station where base station process data through a user-friendly decision making program and all data commands sent to irrigation control station.

T.C. Meyer et al., 2015 [10] represents the design of smart sprinkler system using mesh capable WSN for monitoring and control of field irrigation system. This system provides accuracy by controlling the soil moisture level between the thresholds. Sensor nodes send data to base station every time the timer variable overflows. Base station has an actuator interface to control solenoid valve using GUI. GUI provides system feedback to user and allows changing the parameter and initially setup the system.

Macro Mancuso et al. [11] the Rinnovando group (Rgroup) is working with agriculture experts that concentrate on monitoring microclimate in tomato greenhouse. The main goal of monitoring is to measure when the crop is on risk of developing and the farmer treats the field with fertilizer only when needed.

Nelson Sales et al., 2015 [12] proposed cloud based WSAN communication system, monitoring and control of a set of sensors and actuators to measure water plant needs. Cloud computing provide high storage capacity and high processing capability. The proposed architecture was divided into three components such as a WSAN component, a cloud platform components and a user application component. WSAN contains three types of nodes; sink node, a sensor node and an actuator node.

K.Satish Kannan et al., 2013 [13] proposed a WSN based system that provides an online system to control and maintain the farm remotely by logging into a farming website. Cameras are used to capture live videos of the farm. By using these videos the user is able to see the real condition of the farm and control the farm remotely from any part of the world. The proposed system is divided into three modules: front end measures various parameters and captures live video of the farm, management module controls the irrigation station by gathering real time data and monitoring and control module describes the software part through which the farming website is accessed.

Ravi Kishore Kodali et al.,2015 [14] represents the overall history of spices as black pepper, cardamom and clove in different states where these spices are cultivated and exporters of spices and the problem faced by farming community related to pest and irrigation. Therefore, WSN used to measure different soil and environmental parameter and the presence of pests among crops and provides measured values to the user to take appropriate decisions to improve crop yield. MEMSIC nodes are used for real time monitoring of parameters and control of irrigation system.

CHAPTER 3: MARKET SURVEY

The Smart Irrigation market study offers a comprehensive analysis of the business models, key strategies, and respective market shares of some of the most prominent players in this landscape. Along with an in-depth commentary on the key influencing factors, market statistics in terms of revenues, segment-wise data, region-wise data, and country-wise data are offered in the full study.

Increasing government initiatives to promote water conservation, expanding farming operations cost and growing importance to increase farm profit by utilizing automated irrigation solutions are the primary factors drives the growth of global smart irrigation market. Additionally, increasing research and development investment for developing reliable irrigation scheduling solutions, growing interest on developing smart irrigation solutions using Internet of Things (IoT) and continuous advancement in sensing and monitoring technologies, accelerates the growth of global smart irrigation market. Also, increasing need to monitor and control the water requirements of the field due to inadequate rainfall and water scarcity across the world, further expected to fuel the growth of global smart irrigation market. However, lack of awareness regarding the potential benefits of smart irrigation solutions and high implementation cost are the factors identified as the restraints likely to deter the progression of global smart irrigation market.

The global smart irrigation market is segmented on the basis of component, technology, application and by region. On the basis of component, the global smart irrigation market is segmented into hardware and software, the hardware sub-segment can be further segmented into sensors, controllers, sprinkler nozzles and others. On the basis of technology, the global smart irrigation market is segmented into evapotranspiration based smart irrigation technology and soil moisture based smart irrigation technology. On the basis of application, the global smart irrigation market is segmented into agriculture and non-agriculture. Regionally, the global smart irrigation market is segmented into North America, Latin America, Western Europe, Eastern Europe, Middle East & Africa (MEA), Asia Pacific excluding Japan (APEJ) and Japan.

In this section, the various survey that has been taken for the base decisions on objective information and to compare the results. There were several questions which provided a snapshot of the attitudes and behaviour's including thoughts, opinions and comments about survey populations. And the feedbacks are much valuable to baseline to measure and establish a benchmark from which to compare results over time.

After, visiting the Mushroom farm it was found that there is problem in watering or irrigation the water in mushroom plant where traditional way of irrigation system was still running i.e. pouring water by themselves which consume more water than anything else.

So, to minimize the problem of irrigation and over consumption of water the concept of "Plant Communicator" which will be beneficial to farmer. After that discussion with the farmer of mushroom cultivator and the solution was on our hand with simple and easy solution where got the idea to measure the moisture of spores.

To talk about Internet of Things (IoT) is to be used in the field of agriculture this will help in crop production. Internet of Things (IoT) won't fix the problems related to irrigation but if this can help in boosting crop production in one way or another way and can decrease human labour to some extent. Involvement of technology in this field might make people attracted towards farming.

CHAPTER 4: DESIGN OF EXPERIMENTAL SETUP

4.1 Introduction

The system has three major parts; Moisture sensing part, control section and the output section. The soil humidity was detected using YL-69 soil sensor (a resistance type sensor). The control unit was achieved using ATMega328 microcontroller based on Arduino platform. The output was the unit used to control the irrigation system by switching it on and off depending on the soil moisture contents. Two stages of design were undertaken; hardware and software.

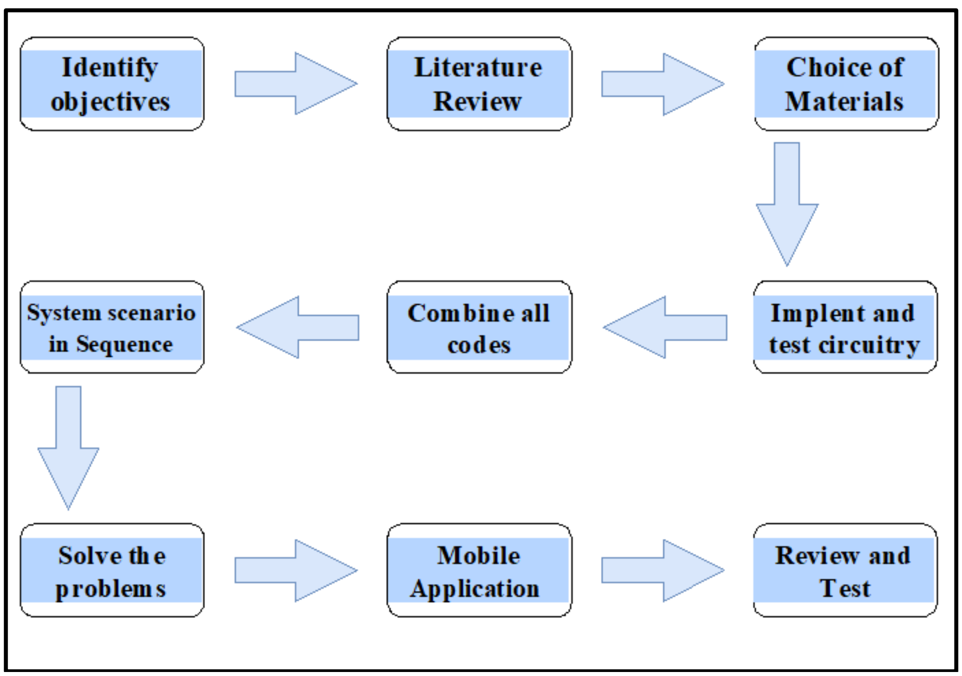


Figure 1: Work Process

4.2 Block Diagram Description

There are four functional components in this project. They are the moisture sensors, microcontroller, IoT and the motor/water pump. Thus the Arduino Board is programmed using the Arduino IDE software. The function of the moisture sensor is to sense the level of moisture in the soil. The motor/water pump supplies water to the plants. NodeMCU is used to send moisture sensor readings to the cloud. These are then fetched by the mobile application.

This project uses Arduino Uno to control the motor. Follow the schematic to connect the Arduino to the motor driver, and the driver to the water pump. The motor can be driven by 5-12 volt. The moisture sensor measures the level of moisture in the soil and sends the signal to the Arduino if watering is required. The motor/water pump supplies water to the plants until the desired moisture level is reached. [15]

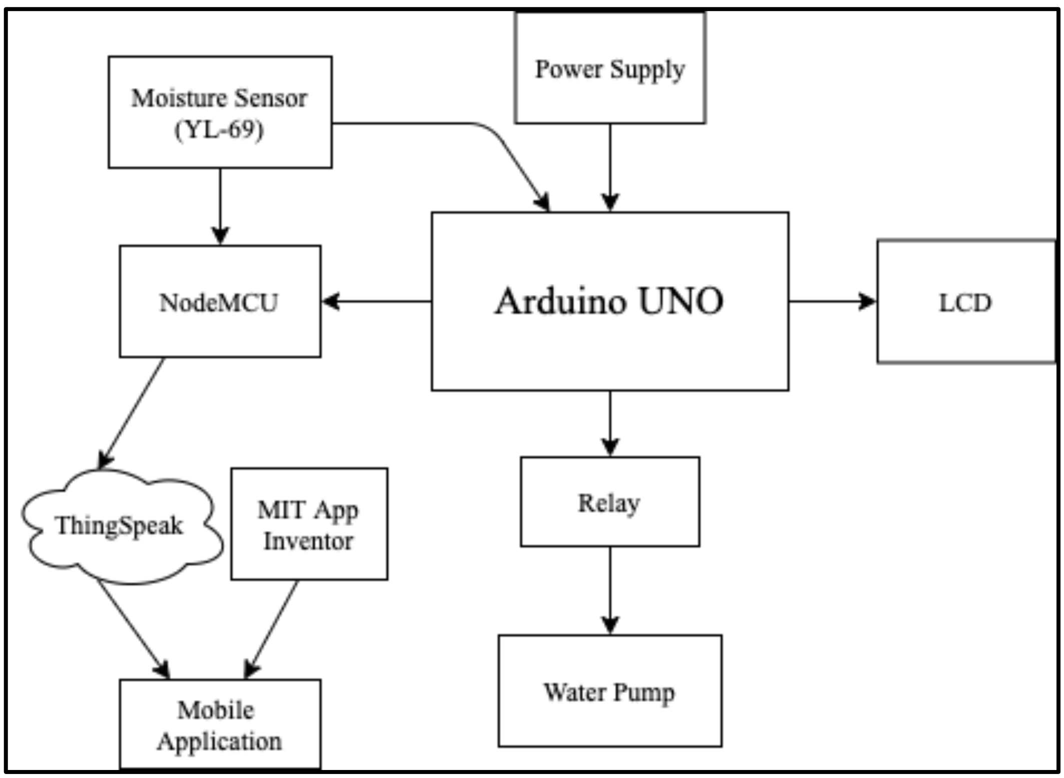


Figure 2: Circuit Block Diagram

CHAPTER 5: DEVELOPMENT OF EXPERIMENTAL SETUP

5.1 Flowcharts

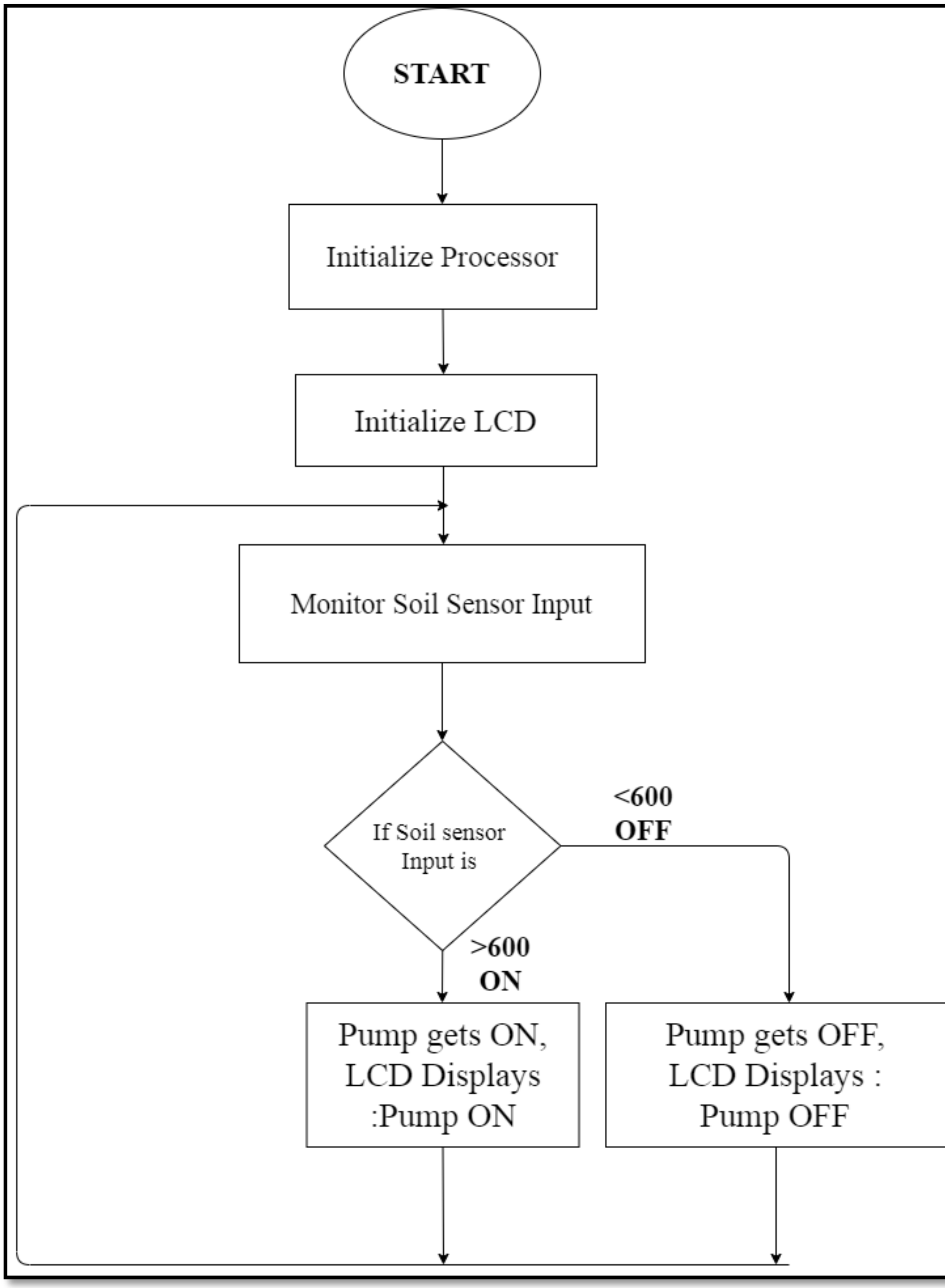


Figure 3: Algorithm for Arduino Uno

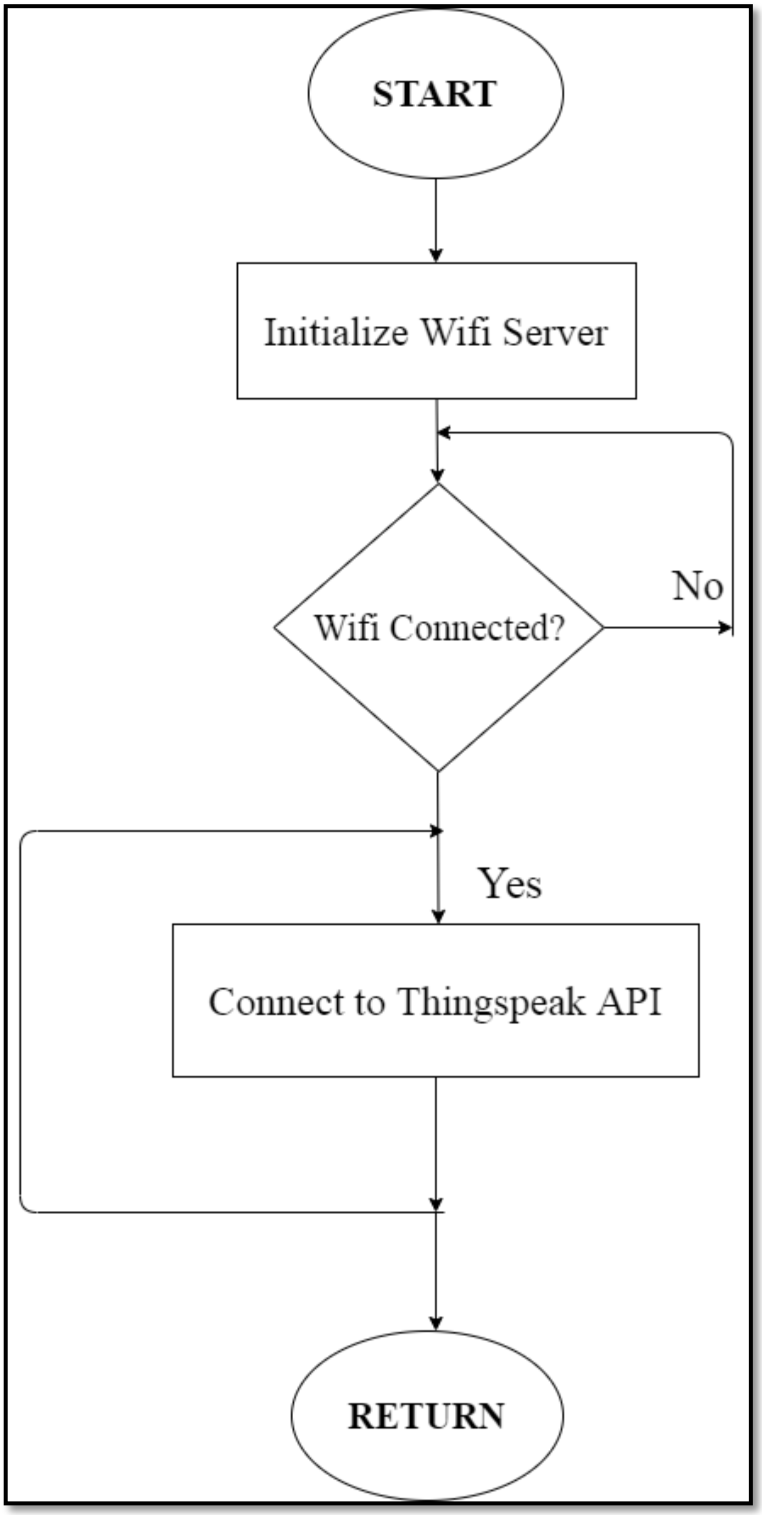


Figure 4:Algorithm for NodeMCU

5.2 Circuit Development

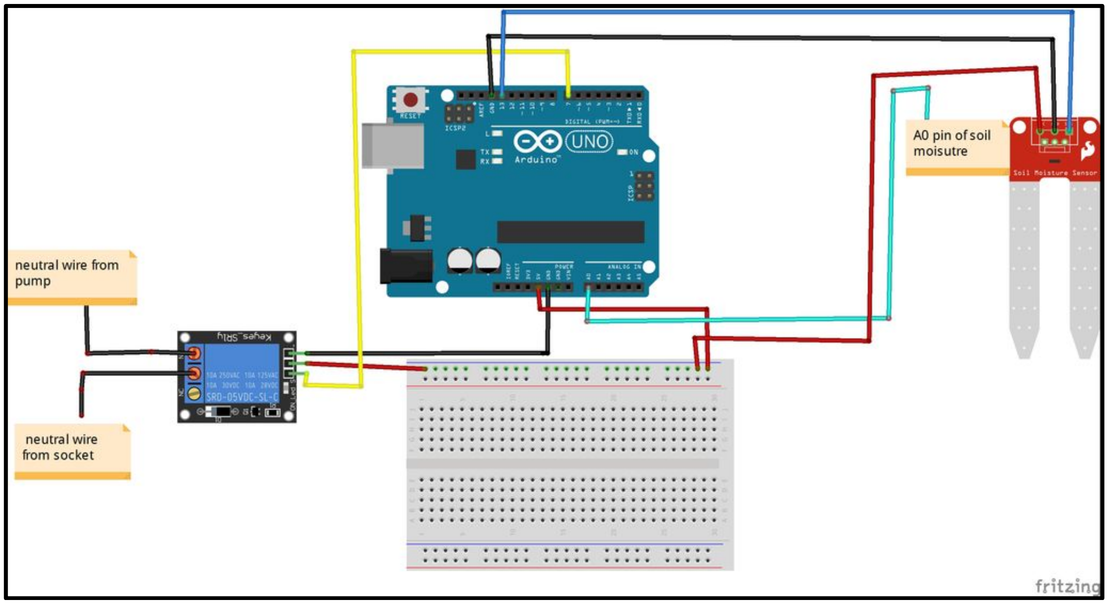


Figure 5: Relay and sensor connections

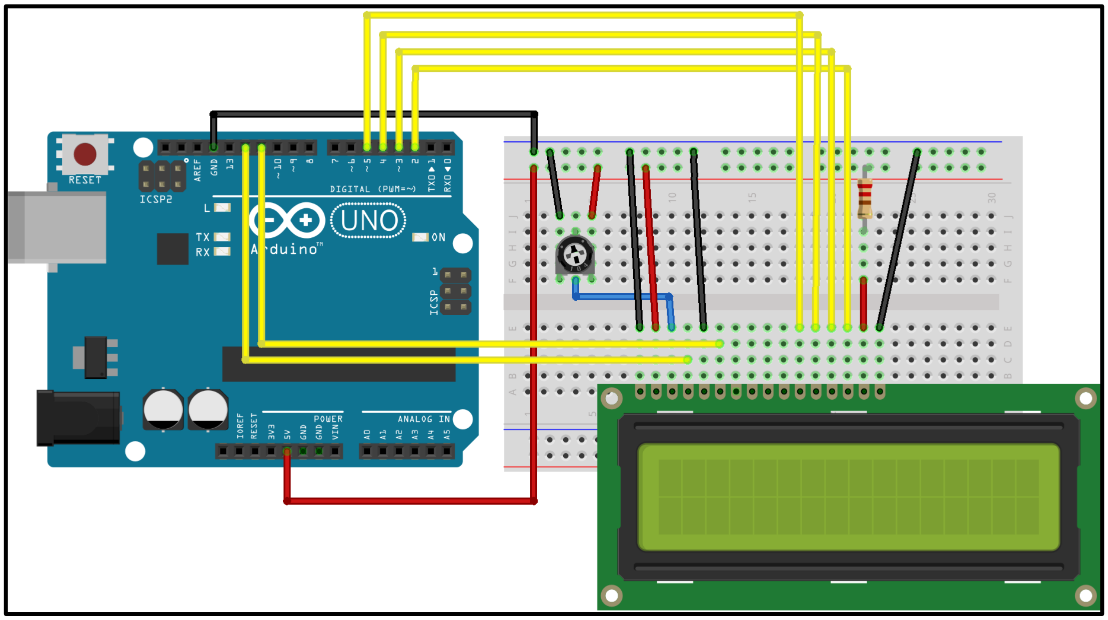


Figure 6: LCD connections

5.3 Hardware-software Interfacings

The Arduino is connected to Laptop and hardware-software interface is done via Arduino ide.

DRY CONDITION:

If the sensed signal is greater than the threshold voltage for every particular soil, it means it executes the true condition and thus the soil is dry. The above statement is based on the property of the moisture sensor, i.e., if the sensed value is greater than or equal to the threshold voltage, then the soil is dry. Because the condition is true, the water pump should turn ON in order to irrigate the plant

WET CONDITION:

If the sensed signal is less than the threshold voltage for every particular soil, it means it executes the false condition and thus the soil is wet. Above statement is based on the property of the moisture sensor, i.e. if the sensed value is less than the threshold voltage, then the soil is wet. Because the condition is false the water pump should turn OFF because the plant has excess of water content in the soil, irrespective of rain.

Threshold	Soil Moisture	Motor condition
>600	DRY	ON
<500	WET	OFF

Table 3: Motor condition for different thresholds

5.4 Overall Project Completion

The work load is distributed evenly among the group members. Numerous methodologies and various technical papers have been looked into and studied for implementing different parts of the project. The different parts of the project involve building the algorithm for training with the input images, research on hardware building and interfacing etc. Based on the understanding of the project the time input has been stated below.

Training is one of the very important tasks of the entire project. Only if the training algorithm and mechanism is working properly can the rest of the project be implemented. So, the very first task that we have taken in hands is to build the hardware properly. The input data need to be fed into the system accurately so as to equip the system to understand and learn better.

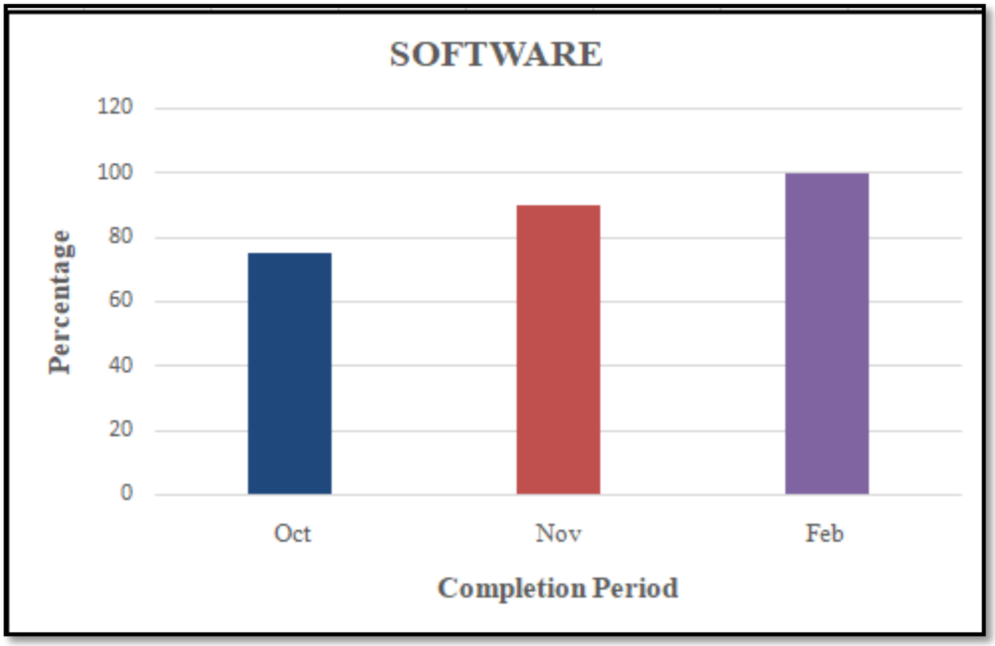


Figure 7: Software work completion

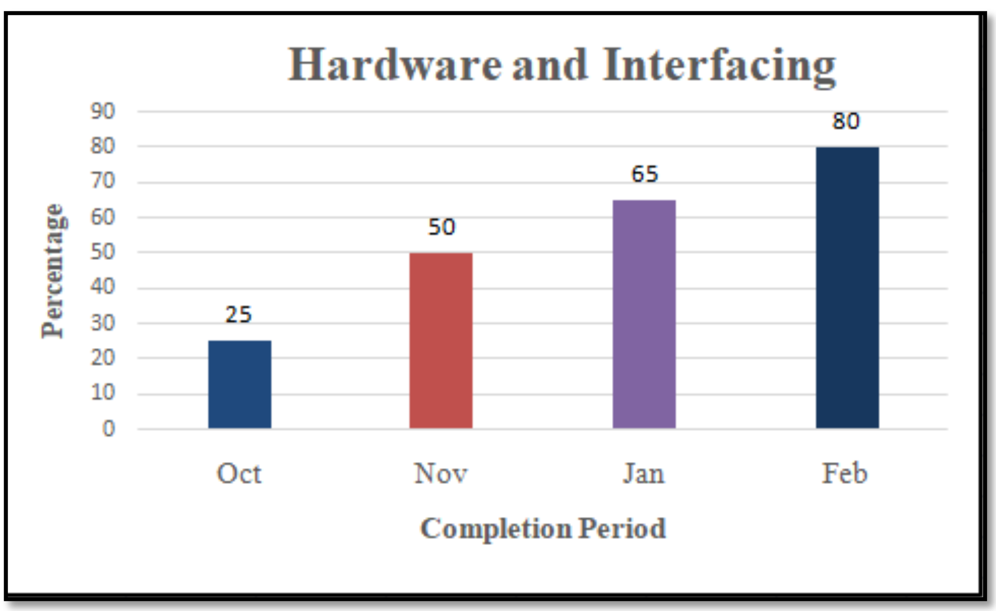


Figure 8: Hardware work completion

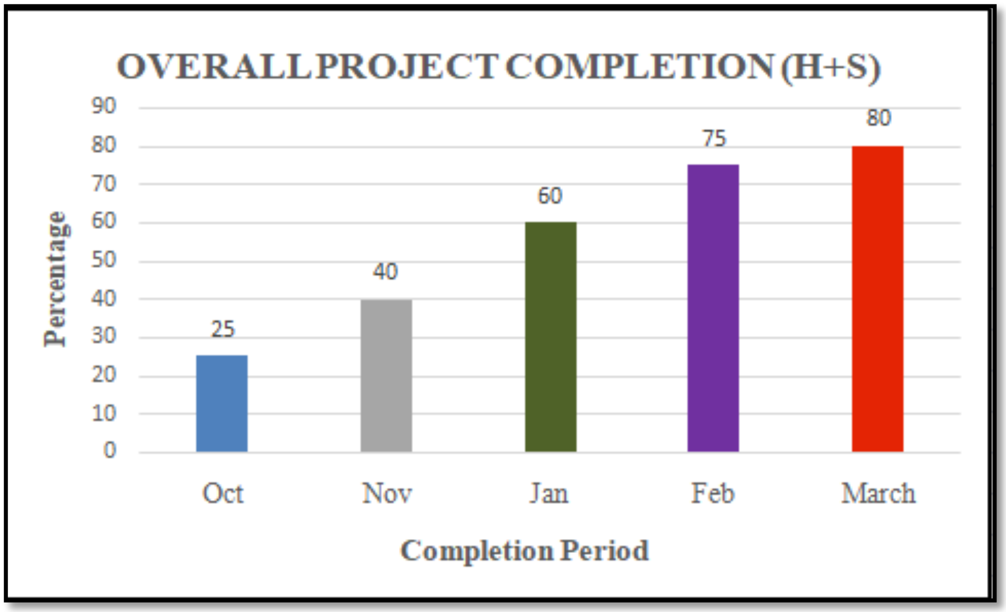


Figure 9: Overall Project Completion

The above bar graphs give the amount of work done in each time span and the project completion details. We have combined the effects taken in both the semesters and made the appropriate graph for each aspect (software, hardware). The work done in the sixth semester post the winter break is to create the prototype of the project system which will help us to visualize the project better in the real time environment. The prototype includes a real life looking agricultural field demo model which has the smart irrigation system installed and help the users get a better understanding of the project and application.

CHAPTER 6: APPARATUS USED IN EXPERIMENTAL SETUP

Main components and software specifications

Main components of our project are as follows:

- YL-69 Moisture Sensor.
- NodeMCU.
- Arduino Uno.
- Liquid Crystal Display (LCD).
- ThingSpeak IoT.
- MIT App Inventor.

6.1 Hardware

6.1.1Arduino Uno Board

The Arduino Uno is an open source board based on the Microchip Atmega328p microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. [16]

Technical specifications:

- Microcontroller: Microchip ATmega328P
- Operating Voltage: 5 Volts
- Input Voltage: 7 to 20 Volts

- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm
- Weight: 25 g

Pins

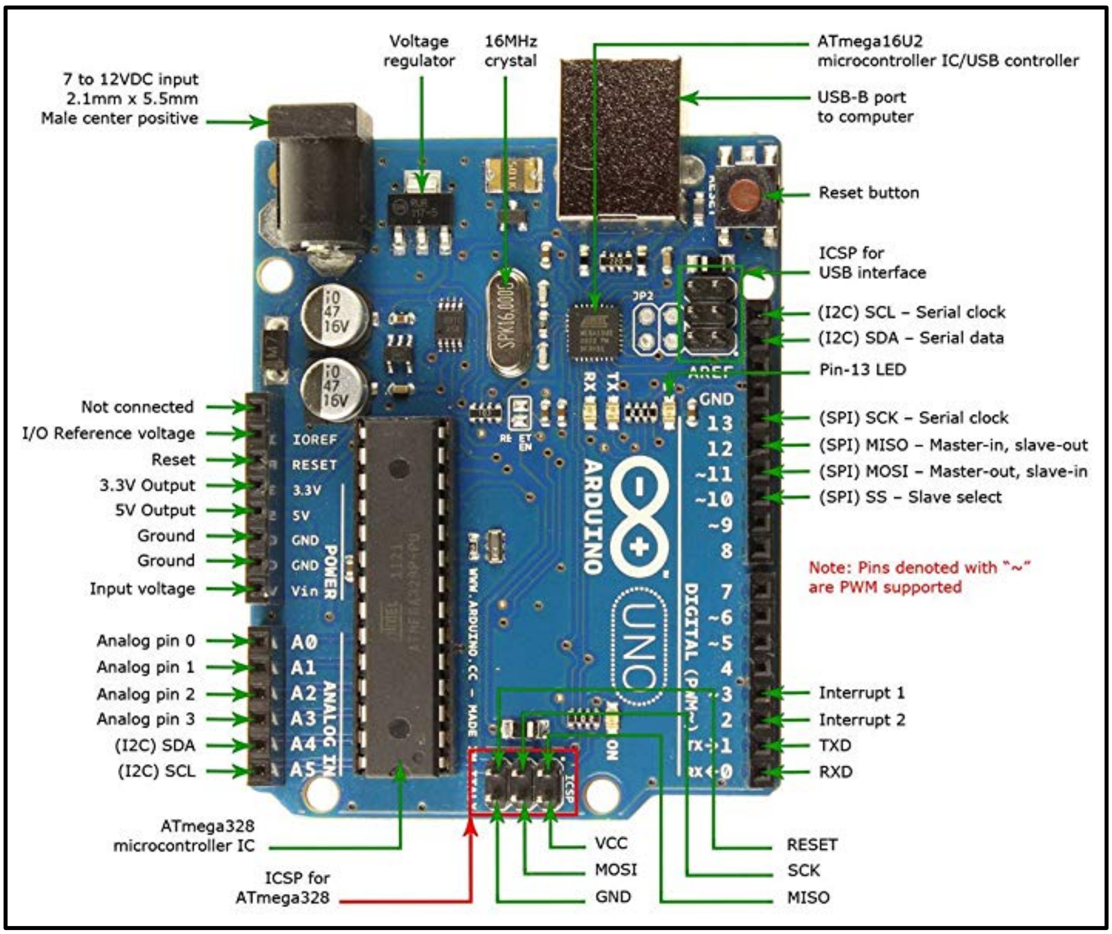


Figure 10: Arduino Uno

General pin functions

- LED: There is a built-in LED driven by digital pin 13. When the pin is high value, the LED is on, when the pin is low, it's off.
- VIN: The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or if supplying voltage via the power jack, access it through this pin.
- 5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 20V), the USB connector (5V), or the VIN pin of the board (7-20V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.
- 3V3: A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND: Ground pins.
- IOREF: This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.
- Reset: Typically used to add a reset button to shields which block the one on the board.

Special pin functions

- Each of the 14 digital pins and 6 analog pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. The Uno has 6 analog inputs, labelled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference () function.

In addition, some pins have specialized functions:

- Serial / UART: pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL serial chip.
- External interrupts: pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- PWM (pulse-width modulation): 3, 5, 6, 9, 10, and 11. Can provide 8-bit PWM output with the analogWrite () function.
- SPI (Serial Peripheral Interface): 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- TWI (two-wire interface) / I²C: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- AREF (analog reference): Reference voltage for the analog inputs.

6.1.2 Liquid Crystal Display (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module which has wide range of applications. A 16×2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16×2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5×7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. [17]

Pins:

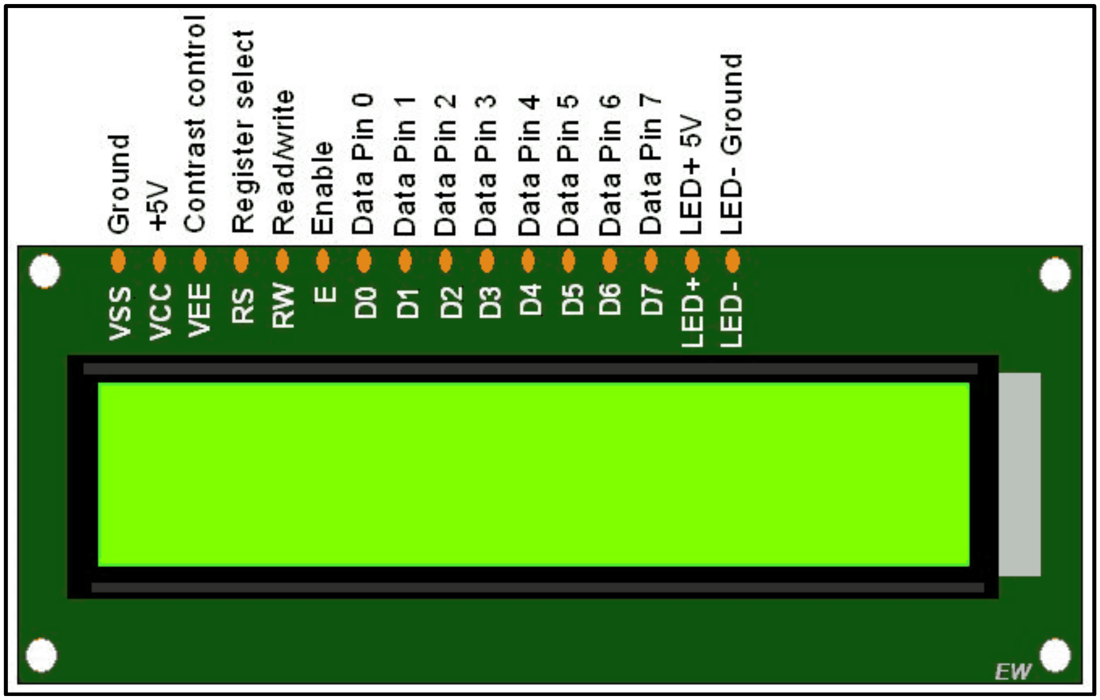


Figure 11: LCD display

6.1.3 YL-69 Moisture Sensor

Product Description

This is a simple sensor that can be used to detect soil moisture/ relative humidity within the soil the module is able to detect when the soil is too dry or wet. Great for use with automatic plant watering systems.

Info / Specs:

- Sensitivity is adjustable via the blue digital potentiometer
- Operating voltage 3.3V-5V
- Module dual output mode: digital output or analog output giving more accuracy
- Has pre-drilled hole for easy installation
- Small board PCB size: 3cm * 1.6cm
- Power indicator (red) and digital switching output indicator (green)
- Uses the LM393 comparator chip

Figure 12 :YL-69 sensor

Connections:

- VCC connect to 3.3V-5V
- GND connect to GND
- DO digital value output connector（0 or 1）
- AO analog value output connector

When the soil is:

- Wet: the output voltage decreases
- Dry: the output voltage increases

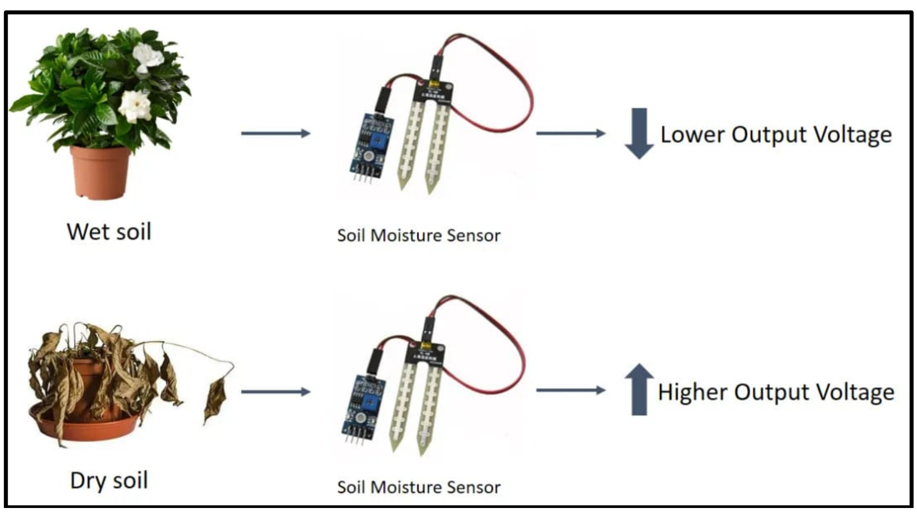


Figure 13: Sensor output for dry and wet soil

The output can be a digital signal (D0), LOW or HIGH, depending on the water content. If the soil humidity exceeds a certain predefined threshold value, the modules outputs LOW, otherwise it outputs HIGH. The threshold value for the digital signal can be adjusted using the potentiometer. The output can be an analog signal and so you'll get a value between 0 and 1023. [18]

6.1.4 NodeMCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson and SPIFFS. [19]

Pins:

NodeMCU provides access to the GPIO (General Purpose Input/Output) and a pin mapping table is part of the API documentation.

I/O index	ESP8266 pin
0 [*]	GPIO16
1	GPIO5
2	GPIO4
3	GPIO0
4	GPIO2
5	GPIO14
6	GPIO12
7	GPIO13
8	GPIO15
9	GPIO3
10	GPIO1
11	GPIO9

12	GPIO10

Table 4: NodeMCU Pin Configuration

[*] D0 (GPIO16) can only be used for GPIO read/write. It does not support open-drain/interrupt/PWM/I²C or 1-Wire.

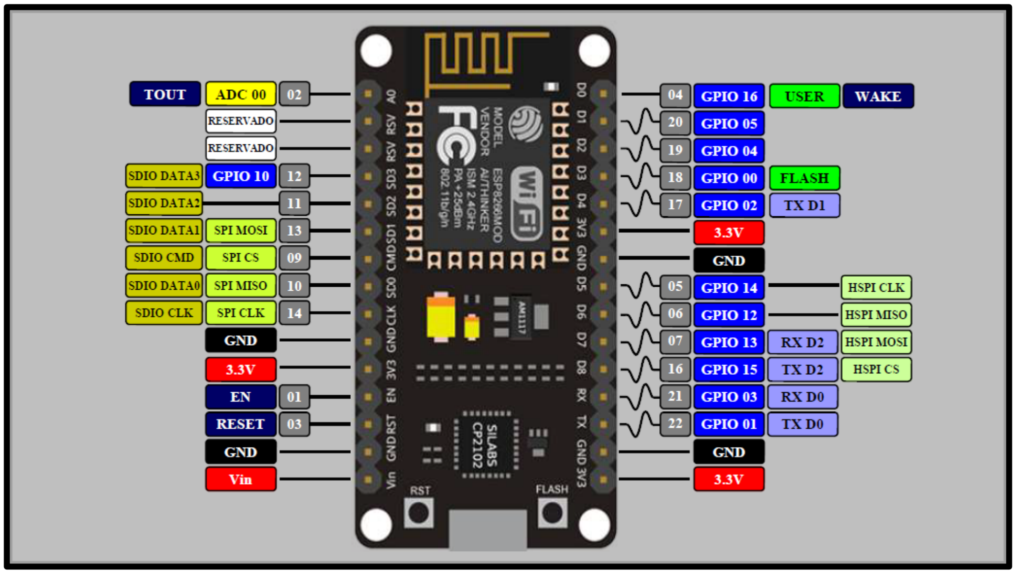


Figure 14: Node MCU

6.1.5 5V Relay Module

5V Relay Module is a relay interface board, it can be controlled directly by a wide range of microcontrollers such as Arduino, AVR, PIC, ARM and so on. It uses a low level triggered control signal (3.3-5VDC) to control the relay. Triggering the relay operates the normally open or normally closed contacts. It is frequently used in an automatic control circuit. To put it simply, it is an automatic switch to control a high-current circuit with a low-current signal. 5V relay signal input voltage range, 0-5V. [20]

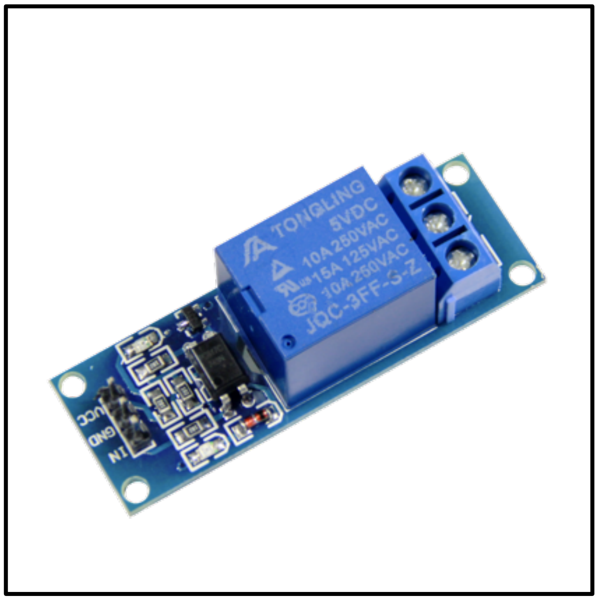


Figure 15: Relay Module

Pin Number	Pin Name	Description
1	Coil End 1	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground
2	Coil End 2	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground
3	Common (COM)	Common is connected to one End of the Load that is to be controlled
4	Normally Close (NC)	The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger
5	Normally Open (NO)	The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger

Table 5: Relay Pin Configuration

6.1.6: Water Pump

The water pump can be defined as a pump which uses the principles like mechanical as well as hydraulic throughout a piping system and to make sufficient force for its future use. At present these pumps are utilized within a wide range of housing, farming, municipal, and manufacturing applications.

The working principle of a water pump mainly depends upon the positive displacement principle as well as kinetic energy to push the water. The water pump is a portable device and can be applied in several household applications. These pumps are used for pumping the huge amount of water from one place to another. The main purpose of a water pump is versatile. A quality pump which can be selected carefully may be perfect for draining water from a low flooded region, refilling the swimming pool, and bathtub, circulating pesticides otherwise fertilizers. [21]

Features:

- Input Voltage: DC 3V-5V
- Flow Rate: 1.2-1.6 L/min
- Operation Temperature: 80 Deg.C
- Operating Current: 0.1-0.2A
- Suction Distance: 0.8 meter (Max)
- Outside diameter of water outlet: 7.5mm
- Inside diameter of water outlet: 5.0 mm
- Diameter of water Inlet : 5.0 mm
- Wire Length: 200 mm
- Size: 45 x 30 x 25 mm
- Weight: 30g

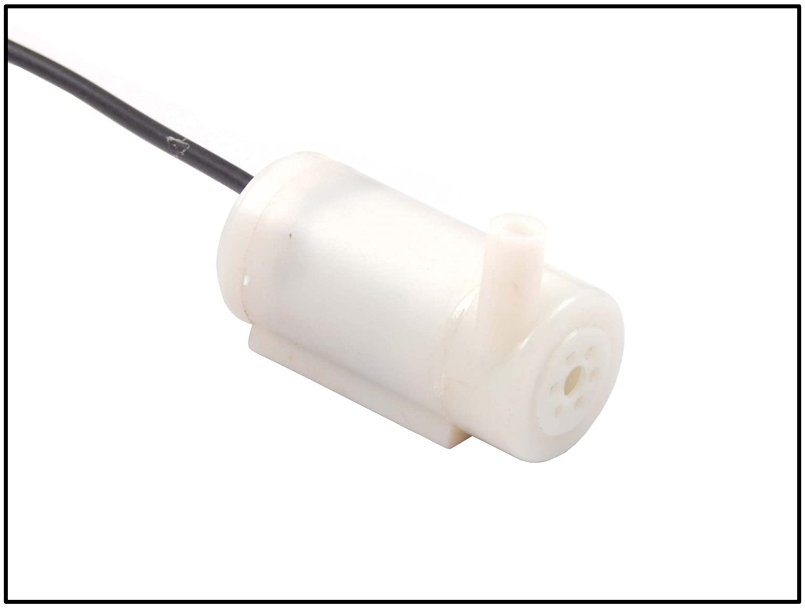


Figure 16: 5V DC Water Pump

6.2 Software

6.2.1 ThingSpeak

According to its developers, "ThingSpeak is an open-source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates".

ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications. [22]

ThingSpeak has integrated support from the numerical computing software MATLAB from MathWorks, allowing ThingSpeak users to analyse and visualize uploaded data using MATLAB without requiring the purchase of a MATLAB license from MathWorks.

ThingSpeak has a close relationship with MathWorks, Inc. In fact, all of the ThingSpeak documentation is incorporated into the MathWorks' MATLAB documentation site and even enabling registered MathWorks user accounts as valid login credentials on the ThingSpeak website. The terms of service and privacy policy of ThingSpeak.com are between the agreeing user and MathWorks, Inc. [23]

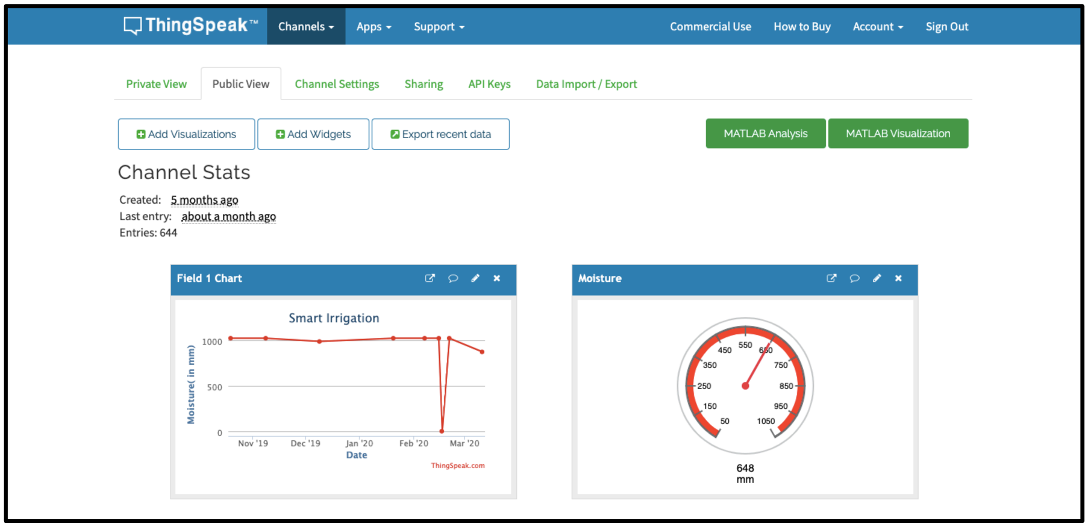


Figure 17: ThingSpeak Page

6.2.2 MIT App Inventor

MIT App Inventor is a web application integrated development environment originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). It allows newcomers to computer programming to create application software (apps) for two operating systems (OS): Android, and iOS, which, as of 8 July 2019, is in final beta testing[citation needed]. It is free and open-source software released under dual licensing: a Creative Commons Attribution ShareAlike 3.0 Unported license, and an Apache License 2.0 for the source code.

It uses a graphical user interface (GUI) very similar to the programming languages Scratch and the StarLogo TNG user interface, which allows users to drag and drop visual objects to create an application that can run on mobile devices. In creating App Inventor, Google drew upon significant prior research in educational computing, and work done within Google on online development environments. [24]

App Inventor and the projects on which it is based are informed by constructionist learning theories, which emphasize that programming can be a vehicle for engaging powerful ideas through active learning. As such, it is part of an ongoing movement in computers and education that began with the work of Seymour Papert and the

MIT Logo Group in the 1960s, and has also manifested itself with Mitchel Resnick's work on Lego Mindstorms and StarLogo. [25]

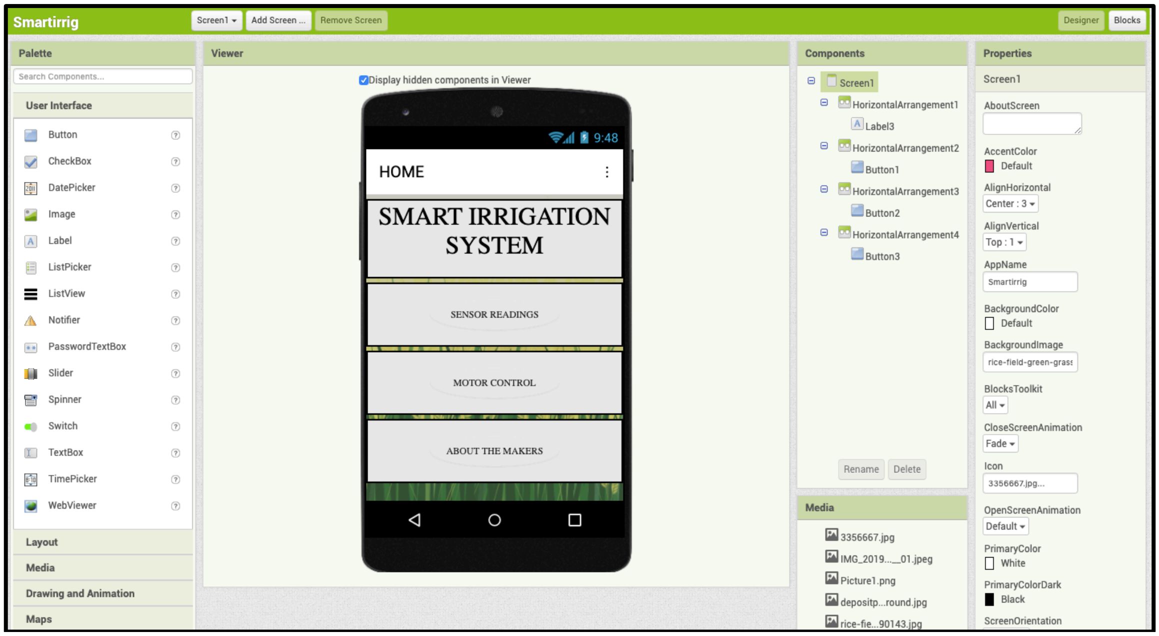


Figure 18: MIT App Inventor page

CHAPTER 7: EXPERIMENTAL OBSERVATIONS

7.1 Circuit Output:

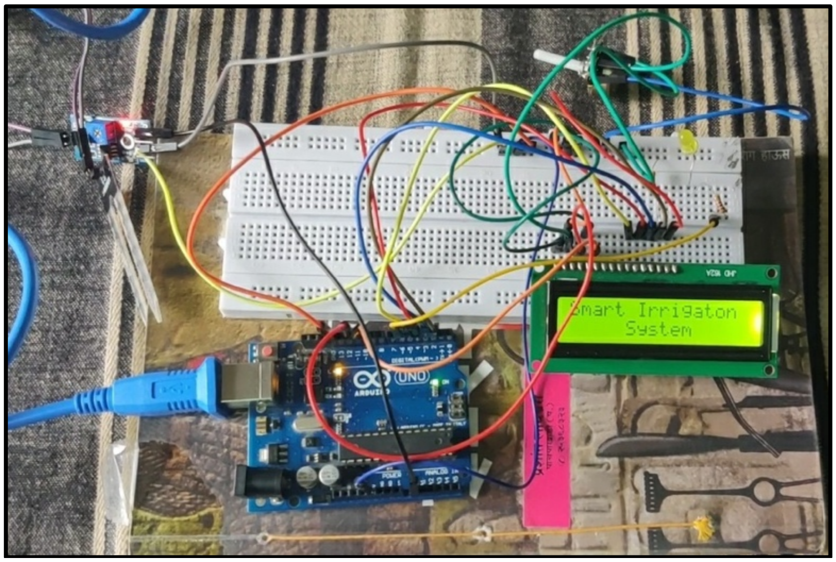
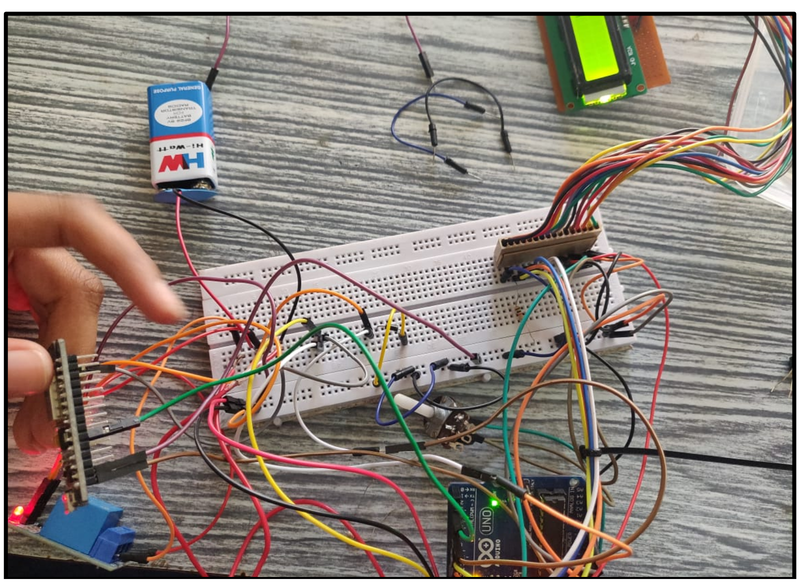


Figure 19: Circuit Connections

The LCD initialises to display the project name i.e. “Smart Irrigation System” The sensor node is deployed in irrigation field for sensing soil moisture and the sensed data is sent to controller node. On receiving sensor value the controller node checks it with required soil moisture value. When soil moisture in irrigation field is not up to the required level then the pump is switched on to irrigate associated agriculture field.



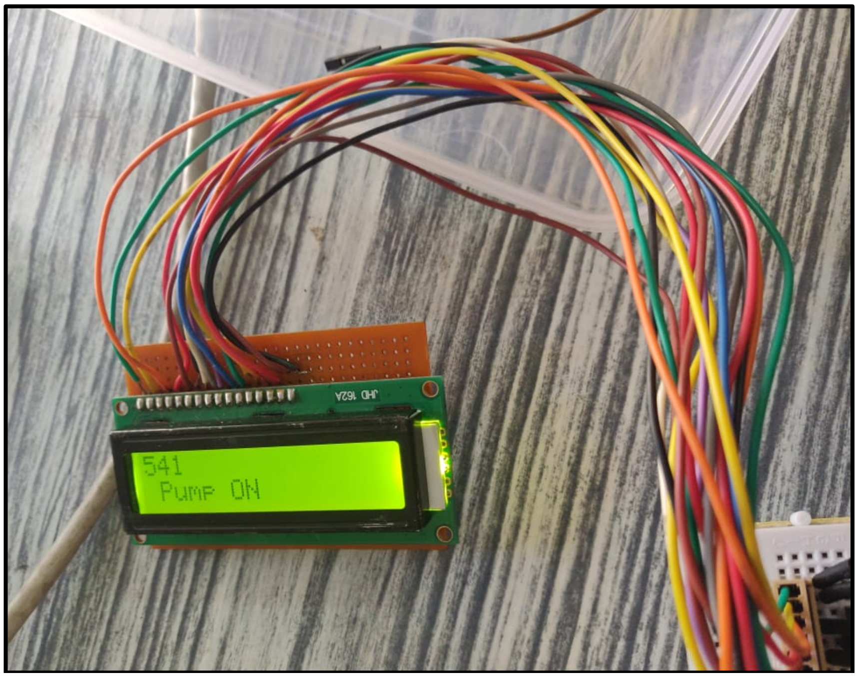


Figure 20: Output on LCD

The project includes a sensor part, controller part and mobile phone part. In sensor node, soil moisture sensor and NodeMCU is integrated with Arduino Uno microcontroller. In controller node, NodeMCU, LCD display are integrated with Arduino Uno microcontroller. The circuit connection is available by connecting all components. As previously provided, the basic connection of the project with LCD, Arduino, breadboard, sensors, potentiometer and connection jumpers is done. The LCD is connected on breadboard directly with LCD display connector with extended wires. The output part includes connecting the Arduino Uno to a relay which then connects to an external battery and the water pump which pumps out the water and hence, provides desired output. A resistor, diode and transistor circuit is employed between Arduino output and the relay to reduce electromagnetic interference.

7.2 Mobile Application:

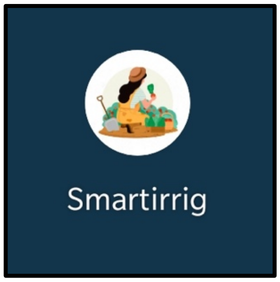


Figure 21: Application logo

Figure 22: Application Screens

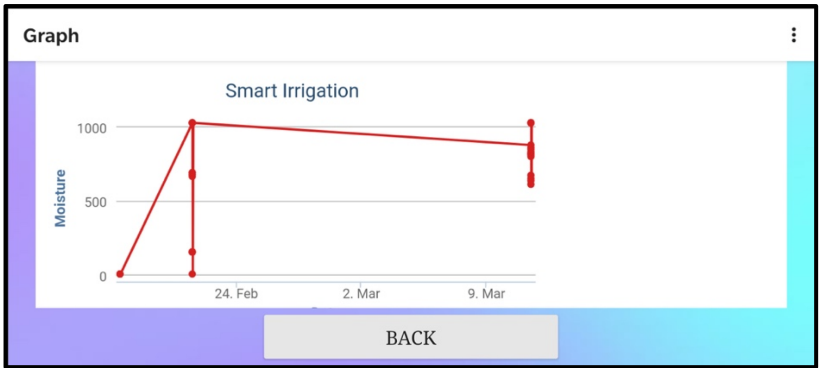


Figure 23: Screen 2

In this semester, we made some changes in the application logo, main Screen and tried to add some new functions and controlling options. In this application one can check real time reading and according to that the project controls the motor. After checking the readings farmer can also see a graphical representation of the change in the reading of the moisture over the period of time (days or months). We also added the information of about the project makers. [26]

7.3 Prototype

Figure 24: Project Prototype module

Figure 25: Project Prototype module

For making the prototype first we took a wooden plot according to appropriate measurements. Then we divided the area of the wooden plot for placing the circuit, trees, showing the farmer's house, etc. which will complete the ambience of a farm. To make it look innovative and attractive we added fences, grass, trees, pond, a house, and a model of the farmer checking the application on his mobile phone. These were made using craft paper, gelatine paper, cardboard and other useful materials.

CHAPTER 8: RESULTS AND DISCUSSION

8.1 Hardware results:

After the completion of the Smart Irrigation System, it has achieved its goal. In this project we have interfaced Moisture sensor with Arduino in order to measure the moisture of the agricultural field. Moisture sensor senses the moisture level (0-1023) and turns the motor ON or OFF according to the given threshold. This is then transferred to the application via a NodeMCU module.

If the sensed value is greater than the threshold, Arduino will send a command to the relay to be energized and to provide water to irrigate the field. If the sensed value is less than the threshold then the relay is deenergized.

Calibration of relay proved to be a problem since we had not used a relay before. But due to guidance and help from the internet and teachers we were able to find the connections suitable for our application.

Further, due to electromagnetic interference from the relay, we received garbage values on the LCD which proved to be a major setback in the project. But due to assistance from our fellow classmates we were able to reduce the interference to some extent and continue with the project.

For the system programming, Arduino Uno ide was used due its simplicity. Programming the hardware part included threshold and LCD programming which was comparatively easy due to previous knowledge of interfacing LCD and to use If/else functions.

8.2 Software Results

The application consists of the information of the current sensor moisture levels and a graph of moisture vs time, present in the field. The application was created using MIT app inventor which was a basic platform to build android projects and it was quite an easy task to do so. The sensed values were uploaded to ThingSpeak database by NodeMCU which was then fetched by the application. It was not easy to program the NodeMCU but with the assist of Arduino library, this system gave positive results.

8.3 Discussion

- The installation of the automated irrigation system is very simple.
- Water savings have not been studied for the system as a whole.
- In the short periods over which this system has been tested, virtually no human intervention was required. The user must only verify that the system is operational and that the water tank, if used, is not empty.
- Further testing should be done in a real home or greenhouse environment to assess the reliability and durability of the system.
- All the components were selected to achieve some degree of power efficiency. All the electronic components consume less than 400mW on a constant basis. The probe consumes a maximum of 41mW, but only for one minute per 5:20-hour duty cycle; in average, it should require less than a milliwatt. On average, the whole system should require less than 450mW of electricity with peak consumption of less than 8.9 W.
- Regular maintenance of the irrigation system is not required, except to refill the water tank .
- No longer only are farmers able to generally use much less water to grow a crop, but they're able to increase growth yields and obtain satisfactory results of the crop by using better management of soil moisture. Hence, precise irrigation control through thus project permits producers to maximize their productivity whilst saving water.

8.4 Advantages:

i. **Saves water** - Studies show that drip irrigation systems use 30 - 50% less water than conventional watering methods, such as sprinklers.

ii. **Improves growth** - Smaller amounts of water applied over a longer amount of time provide ideal growing conditions.

iii. **Saves time** - A timer delay as per environment can be added to the system for automatic watering.

iv. **Helps control fungal diseases** which grow quickly under moist conditions. Also, wet foliage can spread disease.

v. **Adaptable** - A drip irrigation system can be modified easily to adjust to the changing needs of a garden or lawn.

vi. **Simplest Method** - Start by drawing a map of your farm, showing the location of plantings. Measure the distances required for lengths of hose or plastic tubing to reach the desired areas.

Others Advantages [27]

- Highly sensitive
- Works according to the soil condition
- Low cost and reliable circuit
- Complete elimination of manpower

8.5 Disadvantages

- Self-help compatibility is very low with big scale systems, which are very complex.
- Most automated irrigation systems needs electricity.
- For crops like rice we cannot use this same project because of excess need of water.
- It is only a prototype working on DC.
- It currently has only single sensor, so we have limited coverage and accuracy.
- Threshold of only one crop can be used at a type and reprogramming will be required to change it.
- Project is susceptible to harsh environments.
- It has the requirement of being connected to the internet for full functionality.

CHAPTER 9: CONCLUSION

Thus, the "SMART IRRIGATION SYSTEM " has been designed and tested successfully. It has been developed by integrated features of all the hardware components used. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. The system has been tested to function automatically. The moisture sensors measure the moisture level (water content) of the different plants. If the moisture level is found to be below the desired level, the moisture sensor sends the signal to the microcontroller which triggers the water pump to turn ON and supply the water to respective plant using the drip irrigation. When the desired moisture level is reached, the system halts on its own and the water pump is turned OFF. Specific readings from the moisture sensors are also made available on the smart irrigation mobile application. Thus, the functionality of the entire system has been tested thoroughly and it is said to function successfully.

CHAPTER 10: SCOPE FOR FUTURE WORK

To improve the efficiency and effectiveness of the system the following recommendations have been provided:

- With the result of the project first step in the future will be to transfer this project to large.
- One can create more responsive mobile application which has more controlled data.
- We can develop this system by using renewable energy which is solar power instead of batteries using solar energy will help to reduce future cost.
- It can be implemented not in agriculture but in gardens or any place using the sprinkler concept. It has a vast scope when it is mixed with IoT Automation.
- The concept in future can be enhanced by adopting DTMF technology.
- Integrating a technology which can be used; such that whenever the water tank and reservoir is finished, it triggers the LED and alarm indicating “empty” regarding the status of the pump.
- The system can be integrated with soil, temperature, humidity and moisture sensors to monitor the weather conditions, crop yields, rainfall and soil nutrition, etc. of the farm.
- More number of sensors can be calibrated to give an accurate reading of moisture.
- A method of varying the threshold according to the crop can be provided.

REFERENCES

[1] [Online]. Available: http://www.yourarticlelibrary.com/irrigation/major-advantages-and-disadvantages-of-irrigation/60645.

[2] [Online]. Available: https://blog.agrihomegh.com/types-irrigation/.

[3] [Online]. Available: https://sswm.info/sswm-solutions-bop-markets/improving-water-and-sanitation-services-provided-public-institutions-0/crop-selection.

[4] V. A. a. S. A. Ladhake, "Design of Ultra Low Cost Cell Phone Based Embedded System for Irrigation," Kaifeng, China, 2010.

[5] M. L. W. W. C. L. H. G. Man Zhang, Temporal and spatial variability of soil moisture based on WSN, Mathematical and Computer Modelling, Volume 58, Issues 3–4, August 2013, Pages 826- 833,.

[6] B. M. M. E.-B. Sherine M. Abd El-kader, Precision farming solution in Egypt using the wireless sensor network technology, Egyptian Informatics Journal, Volume 14, Issue 3, November 2013, Pages 221-233.

[7] M. A. H. a. P. A. B. Balaji Bhanu, "Monitoring of soil parameters for effective irrigation using Wireless Sensor Networks,," Chennai, 2014.

[8] D. E. H. M. W. J. C. V. M. A. a. O. K. S. Khriji, Precision irrigation based on wireless sensor network," in IET Science, Measurement & Technology, vol. 8, no. 3, pp. 98-106, 2014.

[9] R. G. E. a. W. M. I. Y. Kim, Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network.

[10] T. C. M. a. G. P. Hancke, "Design of a smart sprinkler system,," Macao, 2015.

[11] M. M. a. F. Bustaffa, "A wireless sensors network for monitoring environmental variables in a tomato greenhouse," Torino,Italy, 2006.

[12] O. R. a. A. A. N. Sales, "Wireless sensor and actuator system for smart irrigation on the cloud," Milan, 2015.

[13] K. S. k. a. G. Thilagavathi, "Online farming based on embedded systems and wireless sensor networks," Chennai, 2013.

[14] R. K. K. a. A. Muraleedhar, "WSN in spice cultivation," Noida, 2015.

[15] [Online]. Available: https://www.draw.io/.

[16] [Online]. Available: https://en.wikipedia.org/wiki/Arduino_Uno.

[17] [Online]. Available: https://en.wikipedia.org/wiki/Liquid-crystal_display.

[18] [Online]. Available: https://randomnerdtutorials.com/guide-for-soil-moisture-sensor-yl-69-or-hl-69-with-the-arduino/.

[19] [Online]. Available: https://en.wikipedia.org/wiki/NodeMCU.

[20] [Online]. Available: https://components101.com/5v-relay-pinout-working-datasheet.

[21] [Online]. Available: https://www.cytron.io/p-micro-submersible-water-pump-dc-3v-5v.

[22] [Online]. Available: https://en.wikipedia.org/wiki/ThingSpeak.

[23] [Online]. Available: https://thingspeak.com.

[24] [Online]. Available: https://en.wikipedia.org/wiki/App_Inventor_for_Android.

[25] [Online]. Available: https://appinventor.mit.edu.

[26] [Online]. Available: https://drive.google.com/open?id=1zmN8CtpHPxL5XAdQhVL1kD3waWkWKKpY.

[27] [Online]. Available: https://www.1001artificialplants.com/2019/04/06/advantages-and-disadvantages-of-smart-irrigation-systems/.