AUTO IRRIGATION USING SOIL MOISTURE SENSOR

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ABSTRACT

An automatic irrigation system has been designed to facilitate the automatic supply of adequate of water from a water tank to plants in gardening area. One of the objectives of this work is to see how human control could be removed from irrigation and also to optimize the use of water in the process. The method employed is to continuously monitor the soil moisture level to decide whether irrigation is needed, and how much water is needed in the soil using Arduino Uno. A pumping mechanism is used to deliver the needed amount of water to the soil. The work can be grouped into five subsystems namely; power supply, sensing unit, control unit, pumping system and display system which make up the automatic irrigation system. A soil moisture sensor was used to detect the moisture of the soil and an ultrasonic sensor was used to determine the level of water in tank; a 9V DC power supply was used to power the Arduino Uno and an AC power supply was used to power the water pump; the control circuit was implemented using relay; the pumping system consisting of a submersible AC water pump was used to pump the water to the plants; and the display system consisting of LCD was used to display the AC water pump state of condition and the water level in tank . System response tests were carried out to determine the range and time taken for the system to irrigate the soil. It is seen that the irrigation in Loamy soil generally took longer duration than the irrigation than in Sandy soil. The system helps to eliminate the stress of manual irrigation and irrigation control while at the same time conserving the available water supply.

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ABBREVIATION

ABBREVIATION	DETAILED FACTORS
IDE	Integrated Development Environment
AC	Alternating Current
DC	Direct Current
A	Ampere
V	Voltage
W	Watt
VCC	Voltage at Common Collector
GND	Ground
LCD	Liquid Crystal Display
PWM	Pulse Width Modulation
LED	Light Emitting Diode
PCB	Printed Circuit Board

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Auto Irrigation using Soil Moisture Sensor is a system that provides required amount of water to irrigate the plants in soil. This system helps to irrigate the plants without human intervention. Soil moisture sensor is used to measure the soil moisture level and ultrasonic sensor is used to measure the water level in water tank. The information of water level in water tank and condition of the water pump will be shown using a Liquid Crystal Display (LCD). This project is generally about designing a relay circuit which uses Arduino Uno programming in order to control the irrigation system.

1.2 Background

When it comes to agricultural activities, irrigation in one of the vital process. Irrigation system is an essential important element for plant growth. It also one of major effect in any plant cultivation as it may affect the growth of plants. Irrigation in agriculture term is defined as an artificial application of watering of the arable land or soil. Water is most important to our life and we cannot survive without it. Water also is essential ingredient of plant. An automatic irrigation system helps and encourage people to take care of their plant easily. With the help of soil moisture sensor it will give water automatically to plant. This system will inspire, engage and support people to take their personal responsibility of taking care the environment and making it fun and sustainable. This projects will be implementing using Arduino programming language.

1.3 Problem Statement

Nowadays, automatic plant irrigator system is commonly applied in agriculture such as domestic gardening. In this industry, automatic plant irrigator system usually used to supply water to maintain soil moisture so plants can grow well. Unfortunately, there are still gardeners or farmers who maintained use manually watering technique because not all of them afford to buy the system. Over-watering possibility would occur if this manual process is still practiced. It will caused the plants drown if supply too much water for them. Sometime this manual technique also make the process water late reaches or does not reach the roots of plants and this will cause the plant get dried. Lack of water can be harmful to the plant or even can render it withered. The effect of this lack of water can also slow down the process of plant growth and will also affect the light weight of the plants. An automatic plant irrigation monitoring system is the good solution to overcome this problem. This irrigation system is not only provides a good hydration system for plant but also provides the controller that allows the user to set their irrigation system operation.

1.4 Objective

Our objective for this project is:

a) To design automatic plant irrigator monitoring system to ease the work of people that waters the plants manually.
b) To optimize the use of water efficiently so that future generations won't have to face water crisis.
c) To constantly monitor the moisture of soil so that sufficient nutrients and minerals required for the plants can be absorbed.

1.5 Research Question

In order to achieve the objectives of this project, the following research questions were summarized in designing an automatic irrigation system using soil moisture sensor which optimizes water in an irrigation system.

a) What methods can be used to irrigate the plants?
b) How to get notified about the condition of the moisture level of soil and the depth of water in water tank?
c) What are the possible methods of controlling an automatic irrigation system?
d) How to save cost on creating an automatic irrigation system?

1.6 Scope and Limitation

1.6.1 Scope

This project is a revolution from manual irrigation to automatic irrigation. Soil moisture sensor is used to measure the soil moisture level and ultrasonic sensor is used to measure the water level in the water tank which is controlled by Arduino Uno as the microcontroller of the system.

1.6.2 Limitation

Soil moisture sensor used only has a detection depth of 40 mm which is suitable for limited depth only and also the operating voltage range is 0-5V which cannot withstand high voltage that can cause component malfunction.

LCD supports maximum of 2 lines and up to 16 characters. This may cause difficulties to display more characters in LCD. The operating voltage range of 0-5V which cannot withstand high voltage that can cause component malfunction.

Ultrasonic Sensor (HC-SR04) has maximum sensor angle of 15 degrees and the detection distance of 2cm to 450 cm. The operating voltage range of 0-5V which cannot withstand high voltage that can cause component malfunction.

Arduino Uno R3 which has 14 digital I/O pins and 6 analogue input pins which has been outnumbered by Arduino Mega with more pins. The operating voltage range of 7-12V which cannot withstand high voltage that can cause component malfunction.

AC water pump produces 15W of power. The frequency range is 50-60 Hz. The maximum firing speed of the water pump is about 800 litres per hour. The maximum height of the water travelled from the water pump is about 1 metre.

1.7 Significant

a) To design low cost automatic plant irrigation.
b) The project involves the evolution of manually watering technique to automatic watering technique.
c) The controlling of the automatic watering system in a gardening compound.

1.8 Working Principle and Operation

The automatic irrigation system was designed to continuously sense the moisture level of the soil. The system responds appropriately by watering the soil with the exact required amount of water and then shuts down the water supply when the required level of soil moisture is achieved. A soil moisture sensor was used to determine the level of moisture in the soil. An ultrasonic sensor was used to determine the water level in the tank by measuring the distance between the ultrasonic sensor and the surface of water. The reference level of soil moisture and water level in tank content was made to be adjustable using Arduino Coding. A LCD – LM016L is used to display the moisture level of soil and the water level in tank. A mini buzzer is used to indicate the water level in tank by amplifying its sound when the water level in tank is low or else remain inactive when the water level in tank is high. A submersible low-noise AC water pump was developed to deliver the water to the appropriate parts of the soil (the base of the plants).

The volume of water required for irrigation per time was computed by considering the capacity of the water pump and the water channels. The required irrigation time was determined by considering the response time of the water pump and the water volume required per irrigation instance.

1.9 Summary

In this chapter, the project background, objectives, research questions, scope & limitation, significant and working principle and operation of the system has been stated as above.

Chapter 2

Literature Research

2.1 Introduction

There are many types of automatic irrigation systems on the market but most of the systems has its own advantages and disadvantages. As it can be seen, some systems use different types of components to detect soil moisture. For example, soil moisture sensor module was used to detect the soil moisture in Project 1, but two free resistor leads was used to detect the soil moisture in Project 2. Furthermore, some systems use different types of microcontroller or microprocessor to control the system. For example, Arduino Uno was used to control the system in Project 1, but IC 4011 was used to control the system in Project 2. Different types of automatic irrigation systems have specific objectives based on its requirements.

2.2 Concept / Theory

Project Example 1: Automatic Plant Watering and Soil Moisture Sensing

In this project, soil moisture sensor module is used to measure the soil moisture level. Arduino Uno is used as a microcontroller to control the watering system by using Arduino Programming language. The circuit was constructed using Proteus ISIS software. Transistor is used to control the motor pump of the system. The soil moisture sensor is connected to Arduino Uno. The pump controller circuit board is connected to Arduino Uno. Coding using Arduino programming language is uploaded into Arduino Uno. The drip irrigation kit is set up and connected to the pump. The objective of this project is to automatically water the plants when people are not around and to maintain the mineral in soil that may lost due irregular watering. One of the advantage of this project comes in a complete package form which includes the 5V regulator, a burner, an oscillator, a micro-controller, serial communication interface, LED and headers for the connections. The library examples present inside the software of Arduino. Next, automatic unit conversion capability during debugging. The disadvantages of this project is expensive and small structure.[1]

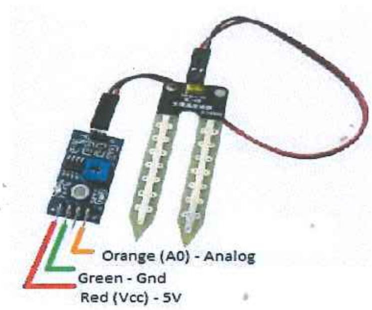

Figure 2.2(a): Soil moisture sensor module

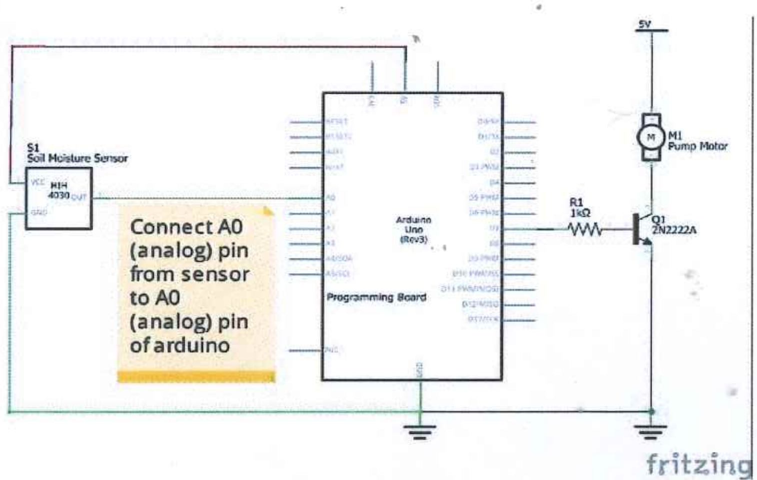

Figure 2.2(b): Circuit diagram of Automatic Plant Watering

Project Example 2: Electronic Soil Moisture Sensor

In this project, two free resistor leads is used to detect the soil moisture and a 9V battery as DC power supply. An IC 4011 is used as the microprocessor of the system. A LED is used to show the soil moisture. Two free 100kΩ resistor leads should not touch each other in the beginning. The LED should be turn on, because the resistance between the two leads is very high. Next, touch the two free leads directly to each other. Then, a small pile of dry soil is put on a plate and touch both resistor leads to the soil at the same time. The LED should turn be turn on, because the resistance of the dry soil is very high. Few drops of water is added to the dry soil as the soil gets wet. Eventually, the LED should turn off because the wet soil has a low resistance. The objective of this project is to design a portable, weatherproof case for a soil moisture sensor circuit and to monitor the soil moisture at multiple places in the garden. The advantages of this project is lightweight, small size, cheap and low power consumption. The disadvantages of this project is limited power rating, operates at low voltage and large value of saturation resistance of transistor.[2]

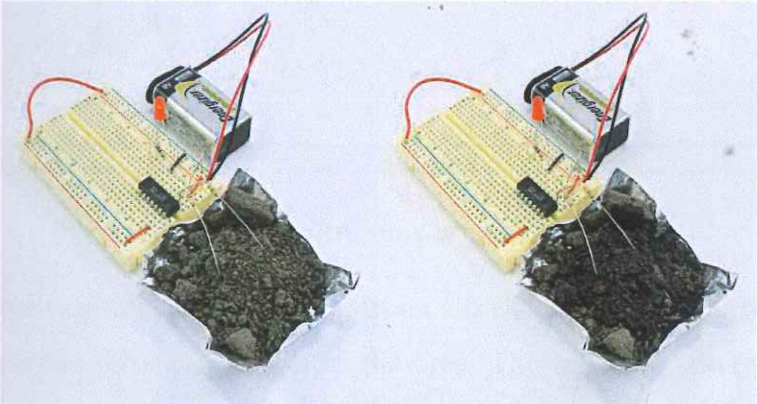

Figure 2.2(c): Circuit connection of Electronic soil moisture sensor

2.3 Primary Research

2.3.1 Ultrasonic Sensor

Ultrasonic sensors project and receive ultrasonic sound energy in a region of interest. Object motion within the region of interest and in the range of the ultrasonic sensor is detected and an alarm signal representative thereof is produced. The effective range of ultrasonic sensors differs from design range whenever the actual ambient atmospheric sound propagation conditions vary from the design or nominal atmospheric conditions.

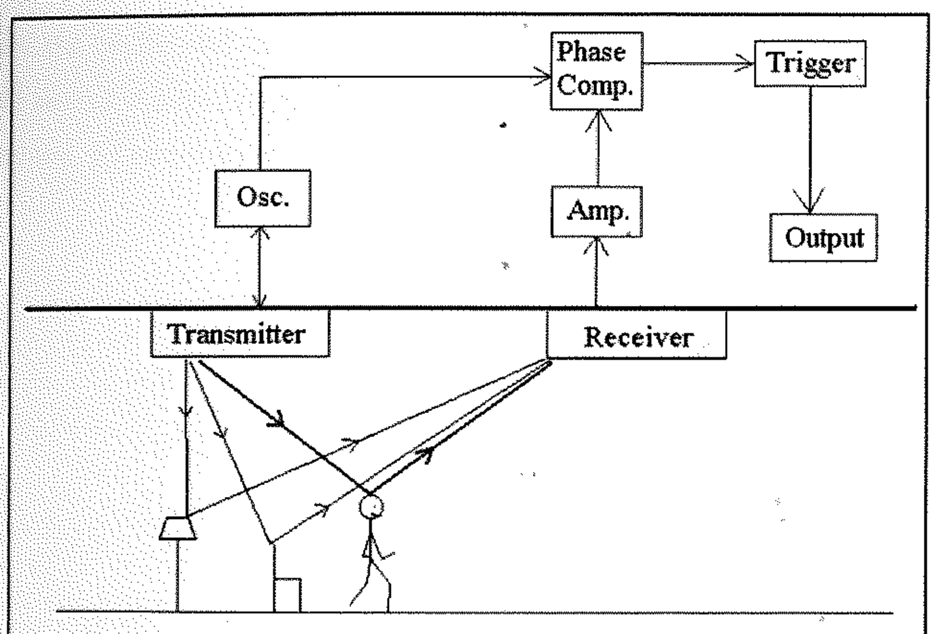

Figure 2.3(a): Ultrasonic sensor operation

There are two transducers: one emits an ultrasonic wave and the other picks up reflections from the different objects in the area. The reflected waves arrive at the receiver in constant phase if none of the objects in the area are moving. If something moves, the received signal is shifted in phase. A phase comparator detects the shifted phase and sends a triggering pulse to the alarm.[3]

2.3.2 Soil Moisture Sensor

Soil moisture sensor is a device which used to measure a physical quantity and convert this information into a signal that can be read by the observer or a tool. The sensor converts one form of energy into another form because the sensor is a transducer. For this reason, the sensor is categorized according to the type of energy transfer that they detected. Soil moisture measurement provides very useful information to agriculture, such as agriculture farm, soil stability, soil moisture and construction activities. The probe selection for sensor is very important. This is because the material that used in the probe. Sensor sensitivity is depending on the material that used to construct the probe and also depends on how the sensor operates. Typically, soil moisture sensor is based on the resistance value of the soil. Water is a type of electric conductance. So generally, if the resistance is low, the soil is dry and vice versa.

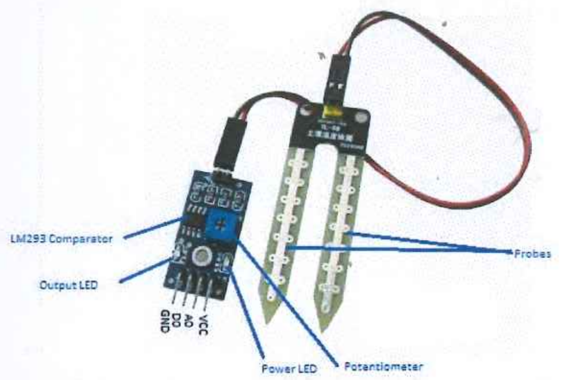

Figure 2.3(b): Soil Moisture Sensor Module

Gypsum block is a product of the low cost soil moisture monitoring. Their low cost and ease of interpretation make this block is particularly suitable for seasonal crops. There are two electrodes embedded in the gypsum block. When gypsum wet, it will conduct electric easily and when gypsum dry, it is a poor conductor. A pair of electrode within the block will measure the change in the resistance. It is possible directly using a pair of electrode measure the resistivity in the soil but the measurement will influence by changes in soil conductivity brought about by salt and other ingredients. The ion gypsum provided a buffer against the effects of salt and nutrients. It is very effective for prevention of salt ions from reaching the electrode and to ensure the sensor is only responding to moisture level.[4]

2.3.3 Arduino Uno

Arduino Uno is a microcontroller that acts as an interface between a computer and the environment (Inputs = sensors, buttons, keypads, etc. Outputs = LEDs, motors, buzzers etc.) It is an open source hardware and software. Hardware and software specs are public and anyone can modify and reproduce them. Many Arduino clones exist (e.g. Freeduino, Seeeduino, Boarduino, etc.). Many different types of Arduino Boards exist, including Lilypad (used for e-textiles), Nano (small footprint), Uno (easily extensible with shields), Mega (large number of I/O pins) etc. We'll use Uno for today's workshop.[5]

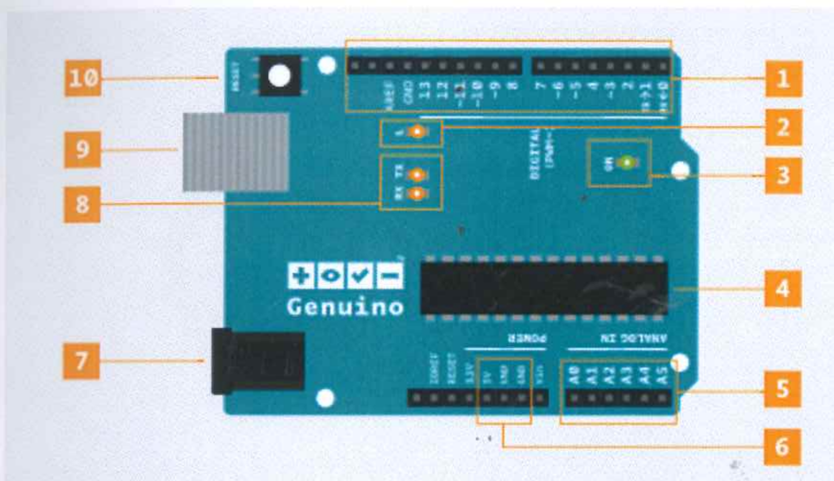

Figure 2.3(c): Arduino Uno Microcontroller

1. **Digital pins** Use these pins with digitalRead(), digitalWrite(), and analogWrite(). analogWrite() works only on the pins with the PWM symbol.
2. **Pin 13 LED** The only actuator built-in to your board. Besides being a handy target for your first blink sketch, this LED is very useful for debugging.
3. **Power LED** Indicates that your Genuino is receiving power. Useful for debugging.
4. **ATmega microcontroller** The heart of your board.
5. **Analog in** Use these pins with analogRead().
6. **GND and 5V pins** Use these pins to provide +5V power and ground to your circuits.
7. **Power connector** This is how you power your Genuino when it's not plugged into a USB port for power. Can accept voltages between 7-12V.
8. **TX and RX LEDs** These LEDs indicate communication between your Genuino and your computer. Expect them to flicker rapidly during sketch upload as well as during serial communication. Useful for debugging.
9. **USB port** Used for powering your Genuino Uno, uploading your sketches to your Genuino, and for communicating with your Genuino sketch (via Serial. println() etc.).
10. **Reset button** Resets the ATmega microcontroller.

Source: http://arduino.cc/en

2.3.4 Water Pump

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps.

Water pump is a device to transport liquid from one place to another. Small-scale water pump which is effective to lift more discharge is generally used. The ones that are most preferred are centrifugal types which having low absorbability. Pump performance is limited by pressure level in real electrical power whereas pump efficiency is influenced by head and discharge.

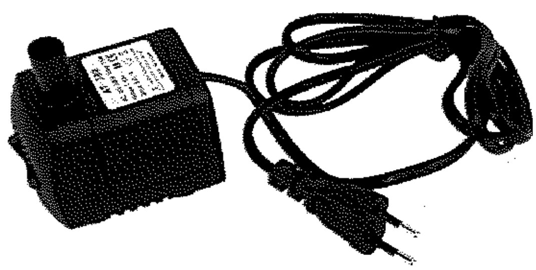

Figure 2.3(d): AC Water Pump

A submersible pump is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between pump and the fluid surface. Submersible pumps push fluid to the surface as opposed to jet pumps having to pull fluids. Submersibles are more efficient than jet pumps.

Electric submersible pumps are multistage centrifugal pumps operating in a vertical position. Liquids, accelerated by the impeller, lose their kinetic energy in the diffuser where a conversion of kinetic to pressure energy takes place. This is the main operational mechanism of radial and mixed flow pumps.[6]

2.4 Summary

In this chapter, concept / theory of few projects related to automatic irrigation system were explained in detail. The primary research for the main electronic components were stated as above.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The auto irrigation using soil moisture sensor system is designed using Proteus ISIS and Proteus ARES to run the system simulation. The simulated circuit is then printed, etched and soldered with required electronic components. A coding was created using Arduino programming language and uploaded into Arduino Uno to control the automatic irrigation system. Few methods of data collection was done to gain knowledge about basic automatic irrigation system. Block diagram and flowchart of the automatic irrigation system was constructed.

3.2 Design

3.2.1 Proteus Design Suite

The Proteus Design Suite is a Windows application for schematic capture, simulation, and PCB (Printed Circuit Board) layout design. The software is used to create schematics and electronic prints for manufacturing printed circuit boards. Schematic capture in the Proteus Design Suite is used for both the simulation of designs and as the design phase of a PCB layout project. It is therefore a core component and is included with all product configurations. The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analogue and digital electronics connected to it. The PCB Layout module is automatically given connectivity information in the form of a netlist from the schematic capture module. It applies this information, together with the user specified design rules and various design automation tools, to assist with error free board design. The 3D Viewer module allows the board under development to be viewed in 3D together with a semi-transparent height plane that represents the boards enclosure.[7] Components used in Proteus ISIS / ARES software:

a) Arduino UNO
b) Ultrasonic Sensor
c) LM35 (replacement for Soil Moisture Sensor)
d) LCD - LM016L
e) Buzzer
f) Relay (G5CLE-1-DC5)
g) Motor (replacement for AC Water Pump)
h) Variable resistor / Potentiometer (10k Ω)
i) Resistors (560Ω, 330Ω)
j) Transistor (BC547)
k) Ground (GND)
l) Power (5V)
m) T-Block (I2, I3)
n) Conn-Sil (2, 3, 4, 6, 8, 10, 18)

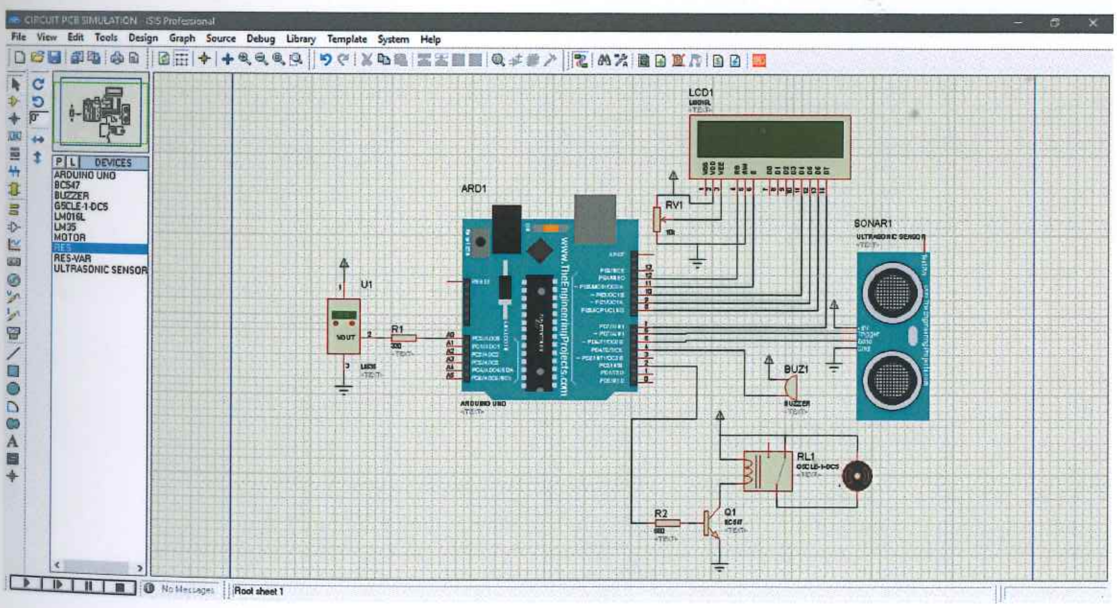

Figure 3.2(a): Proteus ISIS Design

Figure 3.2(a) shows the schematic circuit design of auto irrigation using soil moisture sensor system in Proteus ISIS.

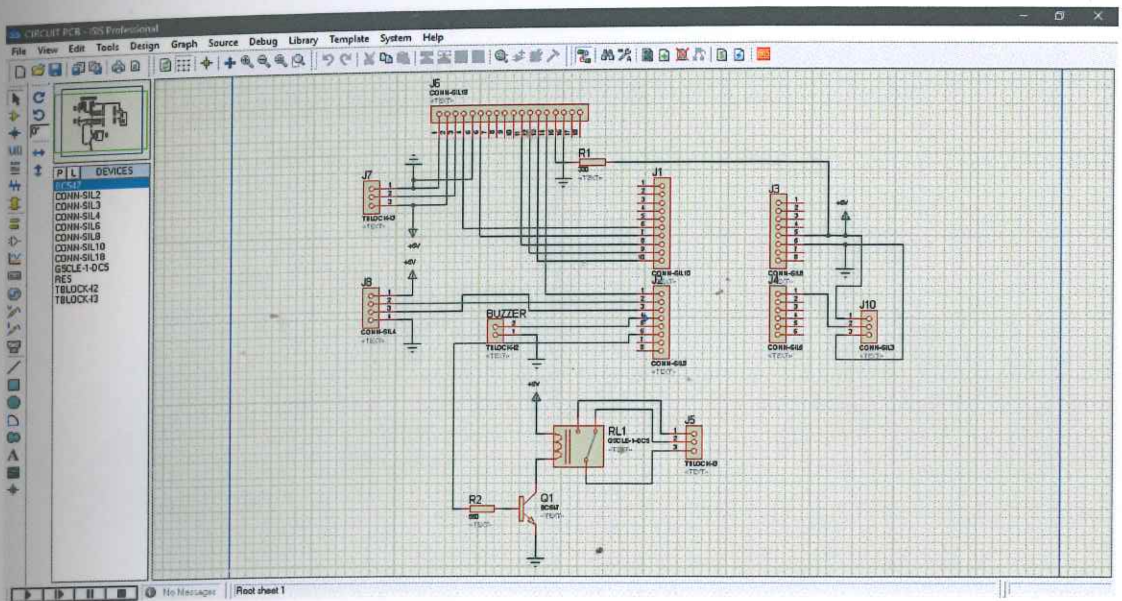

Figure 3.2(b): Converting ISIS to ARES

Figure 3.2(b) shows the conversion of schematic circuit design of auto irrigation using soil moisture sensor system for Proteus ISIS to Proteus ARES.

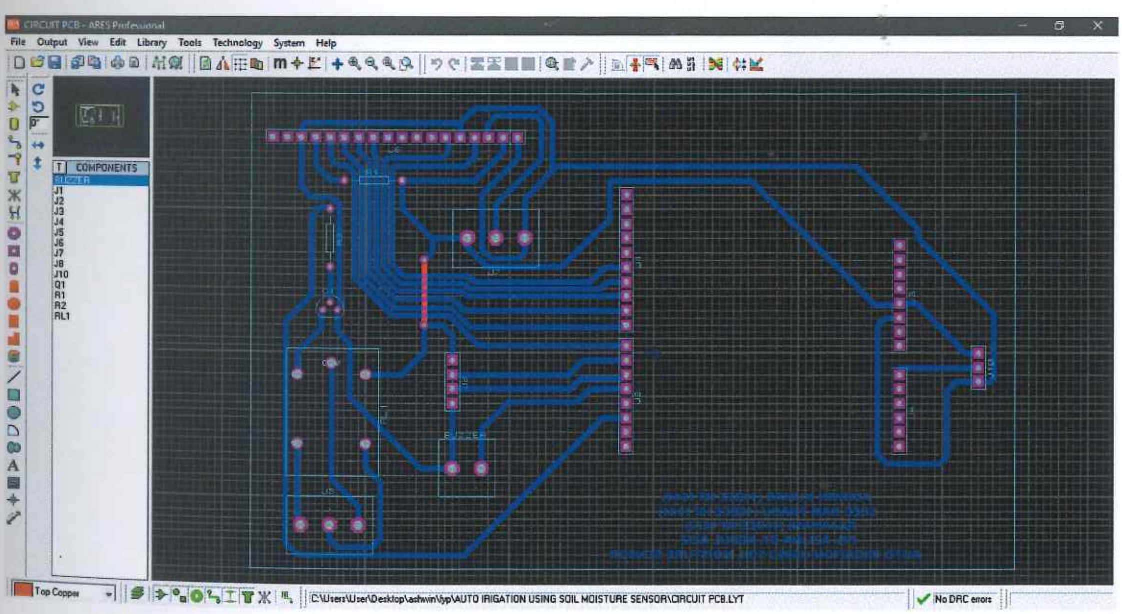

Figure 3.2(c): Proteus ARES Design

Figure 3.2(c) shows the schematic circuit design of auto irrigation using soil moisture sensor system in Proteus ARES.

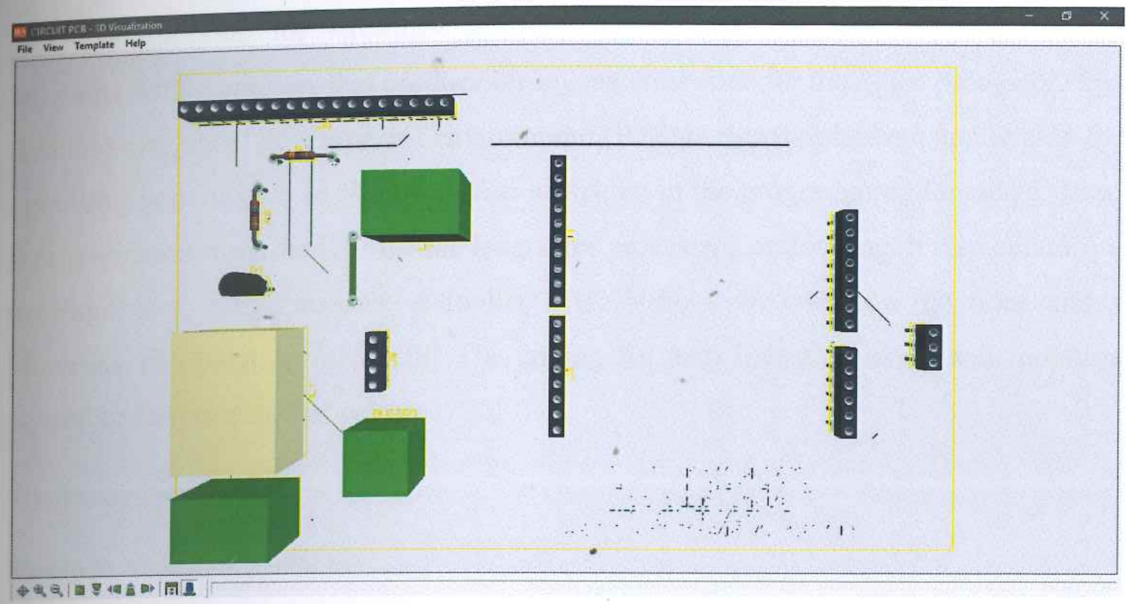

Figure 3.2(d): 3D Visualization (Top View)

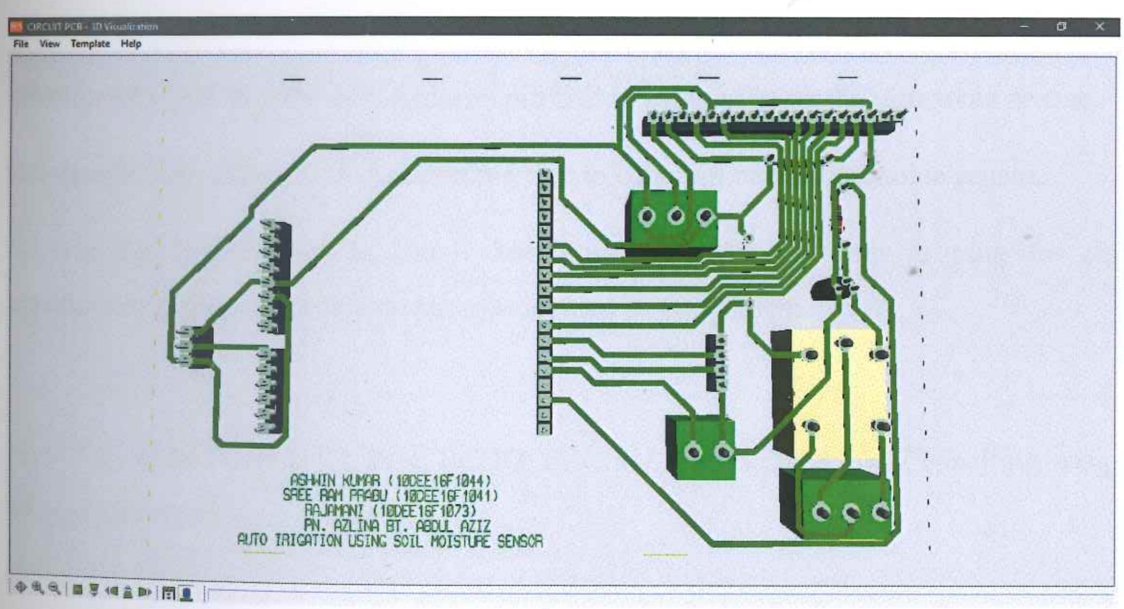

Figure 3.2(e): 3D Visualization (Bottom View)

Figure 3.2(d) and Figure 3.2(e) shows the 3D visualization of the top and bottom view of the PCB.

3.2.2 Arduino Software IDE

A program for Arduino hardware is written using Arduino programming language with compilers that produce binary machine code for the target processor. The Arduino integrated development environment (IDE) is a cross-platform application for operating system such as Windows that is written in the programming language, Java. It is originated from the IDE for the languages processing and wiring. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.[8] The coding for auto irrigation using soil moisture sensor system is stated as below:

```
#include <NewPing.h>

#include <LiquidCrystal.h>

#define buzzer 4

#define relay 2


#define TRIGGER_PIN  6  // Arduino pin tied to trigger pin on the ultrasonic sensor.

#define ECHO_PIN     5  // Arduino pin tied to echo pin on the ultrasonic sensor.

#define MAX_DISTANCE 200 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm.


NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.


LiquidCrystal lcd(12, 11, 10, 9, 8, 7);


void setup() {

 Serial.begin(9600);

 lcd.begin(16, 2);
```

```
 pinMode(buzzer,OUTPUT);
 pinMode(relay,OUTPUT);
 lcd.setCursor(0, 0);
 lcd.print(" AUTO IRIGATION ");
 digitalWrite(relay,HIGH);
 delay(2000);
 lcd.clear();


}


void loop() {
int soilvalue = analogRead(A0);
Serial.println(soilvalue);
lcd.setCursor(0, 0);
lcd.print("WATER LEVEL = " + String(sonar.ping_cm()) + "   ");
if (soilvalue > 800) {
 digitalWrite(relay,LOW);
 lcd.setCursor(0, 1);
 lcd.print("WATER PUMP : ON ");
 delay(2000);
}
else{
 digitalWrite(relay,HIGH);
 lcd.setCursor(0, 1);
```

```
  lcd.print("WATER PUMP : OFF ");
  delay(2000);
 }
 if (sonar.ping_cm()>= 10){
  digitalWrite(buzzer,HIGH);
  lcd.setCursor(0, 1);
  lcd.print("  WATER : LOW   ");
  delay(2000);
 }
 else {
  digitalWrite(buzzer,LOW);
  lcd.setCursor(0, 1);
  lcd.print("  WATER : HIGH  ");
  delay(2000);
 }
 }
```