Smart Watering System using STM32 and ESP8266

Project Report

Submitted in Partial Fulfillment of the Requirement for the Degree of

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ABSTRACT

Nowadays, there is an increasing trend in making devices wireless and user friendly and this project helps to do so by making the user water their plants without having to be physically near the plants to water them.

Existing Smart Irrigation systems are built to monitor moisture content and present it on an LCD display panel. However, it just shows the status of the soil and water pump and is wired to the STM32, so the user can't see the information if they aren't close to the system.

Improving on this, we made this an IOT based project by adding a ESP8266 (Esp-01) WIFI Module to create a Web-Server to remotely display the sensor values as well as control the water pump at the click of a button and also added a DHT11 sensor to detect surrounding Temperature and Humidity. The server is also made global using port forwarding with the help of ngrok so the user can control the pump wirelessly and analyse the conditions from anywhere with a device connected to the internet.

This project is designed to switch ON/OFF the water pump using the button on the ESP-01 webserver and to display the sensor values i.e. DHT-11 (Humidity and Temperature) and Moisture on the Web Server. It is also designed to automatically switch the water pump ON/OFF if the moisture value in the soil is less than a defined limit of Moisture (30%). Additionally, if the temperature or the humidity exceeds predetermined safe levels (Temp>30^{o}C or out of the range 30-60%), it will display an alert to warn the user of harmful temperature conditions.

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Chapter 1

Introduction

1.1.Motivation and Background

In recent times there has been a scarcity of water in rural areas which affects the farmers. Agriculture is both a major cause and casualty of water scarcity. Farming accounts for almost 70 percent of all water withdrawals, and up to 95 percent in some developing countries. We will have to use our natural resources more wisely as time goes on and when it comes to water there is no exception. For example, the choice of crop greatly impacts the amount of water that is needed.

Using this system we can save water, time, money as well the work of the farmers (user) as there is no need for manual intervention.

1.2.Objective:

The objective of the project is to detect and display the moisture content of the soil, temperature and humidity of the surroundings and control the system remotely to water the plants using a Web Server

1.3.Outline and scope:

This report consists of five chapters. The contents of the chapters are as follows:

- Chapter 2 helps us to understand what smart irrigation is.
- Chapter 3 gives us a circuit diagram, its components and their costs.
- Chapter 4 explains the working of the smart irrigations, results and applications.
- Chapter 5 tells us the Conclusion.

1.4.Time plan:

The time plan for our project is described below

Time Plan

	19/07/21	26/07/21	04/08/21	09/08/21	23/08/21	28/08/21	30/08/21	30/08/21	06/09/21	13/09/21	20/09/21	27/09/21	23/10/21	08/11/21
Group Finalization														
Topic Submission														
Topic Finalization														
Ppt Prep and project prep														
Presentation – I														
Ordering Components														
Interfacing components														
Troubleshooting														
Partial Project done														
ESP Programming and Webserver														
Interfaced ESP with STM														
Project and Report Completion														
Final Examination														

Table. 1.4.1 Project time plan

Chapter 2

Smart Irrigation System

2.1.Overview

With the advancement of technology, life is getting simpler and easier in all aspects. In today's world Automatic systems are being preferred over manual system. Automatic system is a growing system of everyday object from industrial machine to consumer goods that can complete tasks while a person is busy with other activities.

Today, the farmers are suffering from the lack of rains and scarcity of water. The main objective is to provide an automatic irrigation system thereby saving time, money & power of the farmer. The traditional farmland irrigation techniques require manual intervention. With the automated technology of irrigation the human intervention can be minimized. Whenever there is a change in temperature and humidity of the surroundings these sensors sense the change in temperature and humidity and give an interrupt signal to the microcontroller to turn on/off the pump.

2.2.What is Smart Irrigation ?

Smart irrigation systems use sensors for real-time to inform watering routines and modify watering schedules to improve efficiency**.** Approximately 50% of water is wasted due to overwatering caused by inefficiencies in traditional irrigation methods and systems. Smart irrigation technology is the answer. Smart irrigation systems tailor watering schedules and run times automatically to meet specific landscape needs. These controllers significantly improve outdoor water use efficiencies. Unlike traditional irrigation controllers that operate on a preset programmed schedule and timers, smart irrigation controllers monitor weather, soil conditions, evaporation and plant water use to automatically adjust the watering schedule to actual conditions of the site.

Essentially there are two types of smart irrigation controllers: weather-based (ET) and on-site soil moisture sensors. The right solution depends on your geographic location and landscape environment.

Weather-based controllers, also referred to as evapotranspiration (ET) controllers, use local weather data to adjust irrigation schedules. Evapotranspiration is the combination of evaporation from the soil surface and transpiration by plant materials. These controllers gather local weather information and make irrigation run-time adjustments so the landscape receives the appropriate amount of water.

ET weather data uses four weather parameters: temperature, wind, solar radiation and humidity. It's the most accurate way to calculate landscape water needs.

There are three basic forms of these weather-based ET controllers:

1) Signal-based controllers use meteorological data from a publicly available source and the ET value is calculated for a grass surface at the site. The ET data is then sent to the controller by a wireless connection.
2) Historic ET controllers use a pre-programmed water use curve, based on historic water use in different regions. The curve can be adjusted for temperature and solar radiation.
3) On-site weather measurement controllers use weather data collected on-site to calculate continuous ET measurements and water accordingly.

Soil moisture sensor-based smart irrigation controllers use one of several well-established technologies to measure soil moisture content. When buried in the root zone of turf, trees or shrubs, the sensors accurately determine the moisture level in the soil and transmit this reading to the controller.

There are two different soil moisture sensor-based systems available:

- Suspended cycle irrigation systems, which are set like traditional timer controllers, with watering schedules, start times and duration. The difference is that the system will stop the next scheduled irrigation when there is enough moisture in the soil.
- Water on demand irrigation requires no programming of irrigation duration (only start times and days of the week to water). It has a user-set lower and upper threshold, which initiates irrigation when the soil moisture level fails to meet those levels.

Chapter 3

Circuit Diagram and Components with costing

3.1 Block Diagram

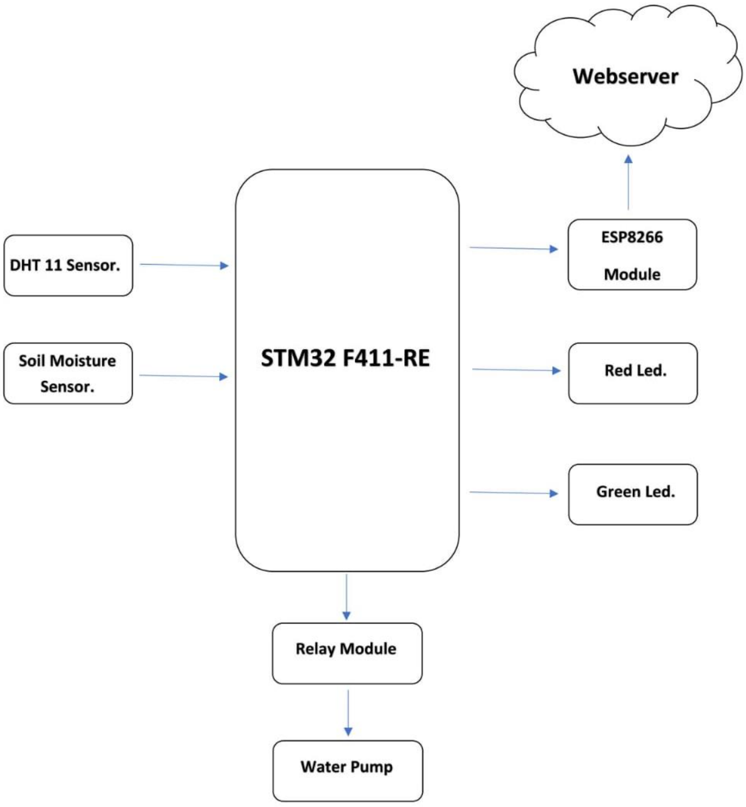

Fig 3.1.1 : Block diagram

The STM32 is the heart of the project which takes input from DHT11, Analog moisture sensor and also from the ESP8266 wifi module to run the relay which will control the motor.The ESP8266 module will host a web server on its local IP which we further make global by port forwarding using ngrok.

3.2.Components :

1) STM32 F411-RE:

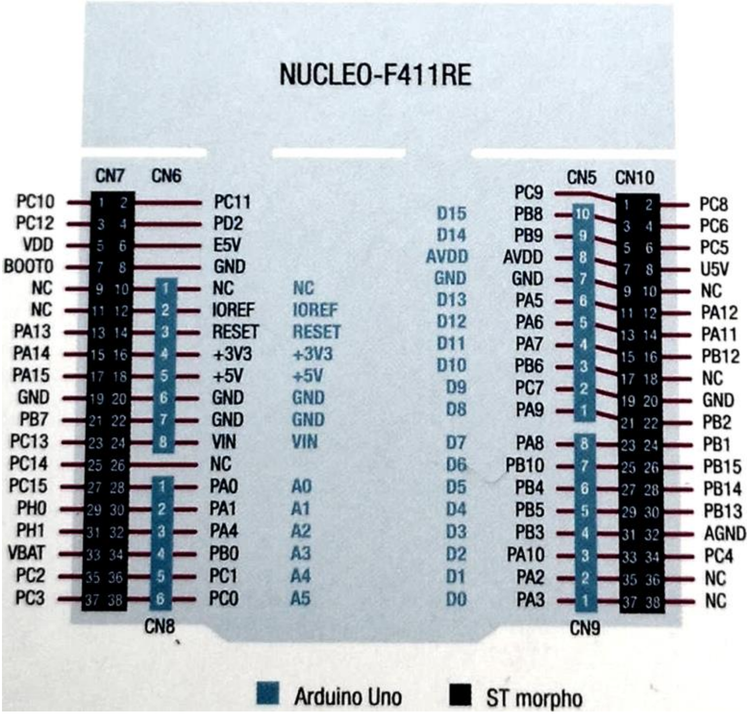

Fig 3.2.1 : Pin Diagram of STM

STM32 are a family of 32-bit microcontrollers made by STMicroelectronics. These microcontrollers feature the ARM Cortex-M processors which are designed for low-power operation, efficiency and low-cost.

STM32 ARM-based micros from STMicroelectronics pack high density resources than any other conventional microcontroller. The I/O ports in STM32 are usually named as GPIOA, GPIOB, etc. and are 16 bit wide.

Some IOs are 5V tolerant and are labelled “FT” in datasheets and other docs. The rest of the I/O pins are not that tolerant and so 3.3V operation should always be ensured I/O pins can source or sink currents up to 25mA.

Thus direct LED drive is possible with them. To drive loads that need more than this value, we must use external BJTs, MOSFETs, optocouplers, transistor arrays or other driver devices.

2) ESP8266-01

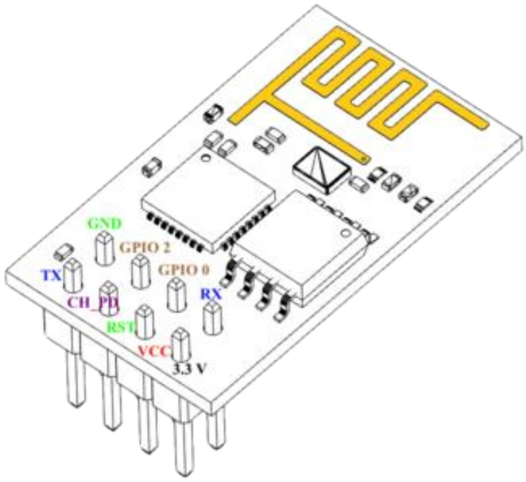

Fig 3.2.2 : Pin Diagram of ESP8266 (ESP-01)

The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability, produced by Espressif Systems in Shanghai, China.

This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands.

The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing the building of single-chip devices capable of connecting to Wi-Fi.

3) Analog Soil moisture sensor:

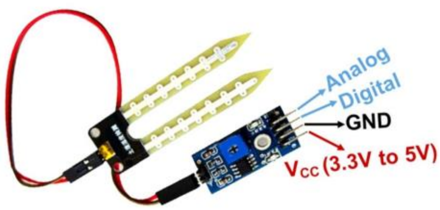

Fig 3.2.3 : Analog Soil Moisture Sensor

A soil moisture sensor can read the amount of moisture present in the soil surrounding it. It's an ideal for monitoring an urban garden, or your plant's water level. It is a necessary component in an IOT garden / Agriculture.

This soil moisture arduino sensor uses the two probes to pass current through the soil, and then it reads that resistance to get the moisture level. More water makes the soil conduct electricity more easily (less resistance), while dry soil conducts electricity poorly (more resistance).

4) DHT 11 Sensor:

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). You can get new data from it once every 2 seconds.

Comes with a 4.7K or 10K resistor, which you will want to use as a pullup from the data pin to VCC.

The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measures and processes these changed resistance values and converts them into digital form. For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature.

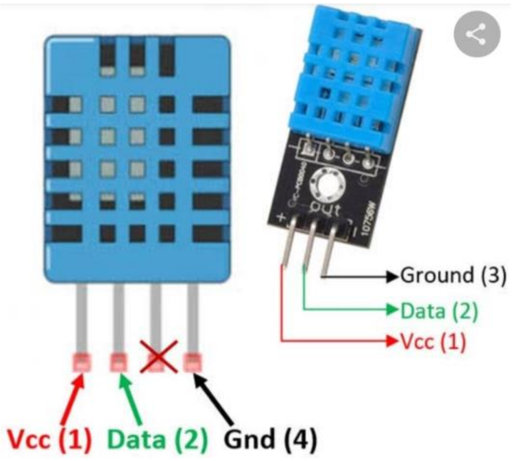

Fig 3.2.4 : Pin Diagram of DHT11 Sensor

5) <u>4 Channel 5V Relay module:</u>

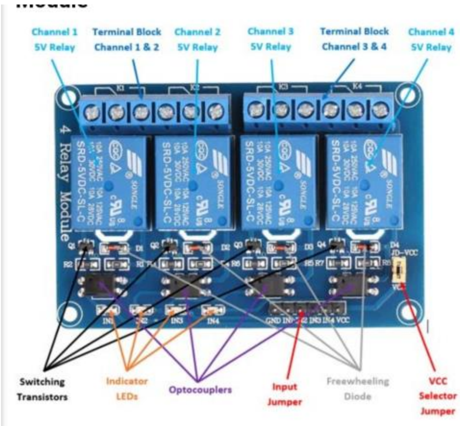

Fig 3.2.5 : Relay Module

A relay basically allows a relatively low voltage to easily control higher power circuits.

The four-channel relay module contains four 5V relays and the associated switching and isolating components. The contacts on each relay are specified for 250VAC and 30VDC and 10A in each case.The switching transistors act as a buffer between the relay coils that require high currents, and the inputs which don’t draw much current. They amplify the input signal so that they can drive the coils to activate the relays.

The freewheeling diodes prevent voltage spikes across the transistors when the relay is turned off since the coils are an inductive load. The indicator LEDs glow when the coil of the respective relay is energized, indicating that the relay is active. The optocouplers form an additional layer of isolation between the load being switched and the inputs.

3.3. Costings

Serial No.	Component Name
1	STM32F411RE
2	ESP8266 Wifi Module
3	Analog Moisture Sensor
4	DHT11 Temperature & Humidity Sensor
5	Breadboard
6	Jumper Wires
7	LED
8	5V DC Motor
9	5V Relay
10	7805 Voltage Regulator
11	9V Battery

Table 3.3.1 Costing of the components.

Chapter 4

Physical Hardware, Working and Applications

4.1.Smart Irrigation

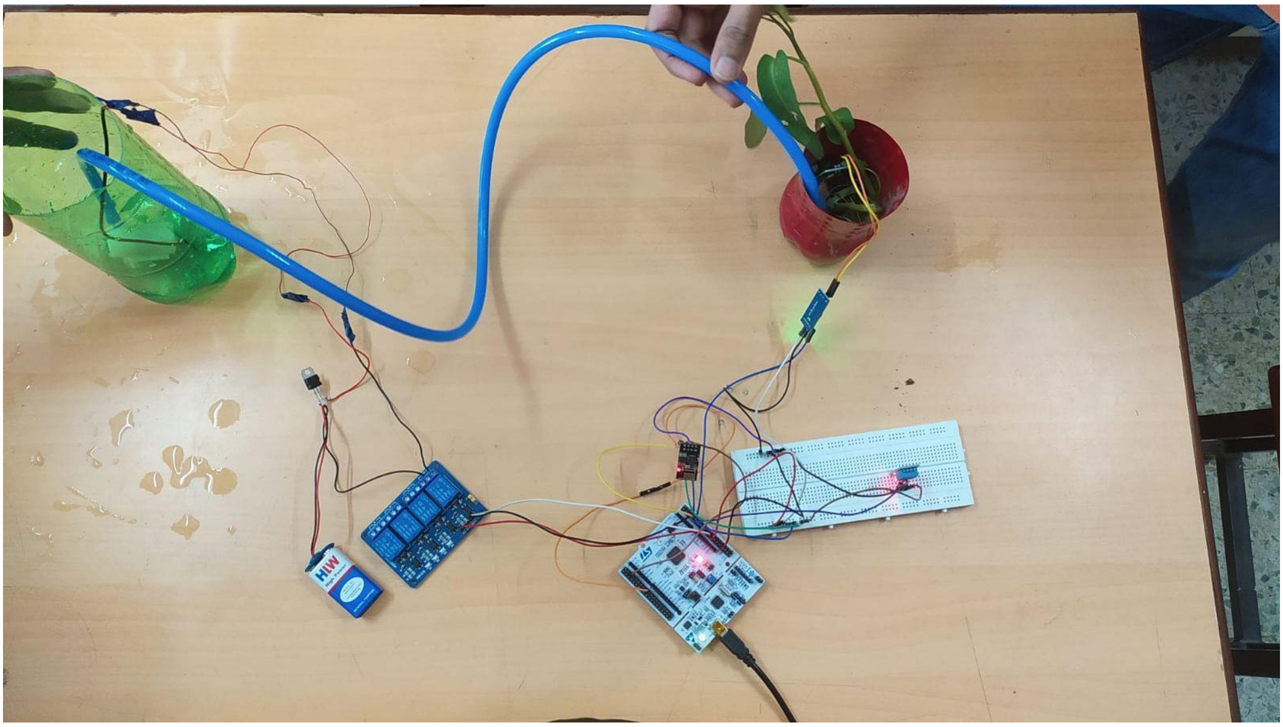

Fig 4.1.1 : Hardware Circuit

4.2. Working:

1. Working of STM32:
    - Makes connection with ESP8266 Wifi module for generating a web server to display the sensor values and control the motor.
    - The Stm will sense the moisture values using the Analog Moisture Sensor as well as the Temperature and Humidity values using DHT11 sensor.
    - The STM32 will store all the sensor values in its flash memory.
    - It will then send these sensor values to the ESP8266 module.
    - It will also take an input from ESP8266 to turn ON and OFF the motor using webserver.
    - STM32 controls the motor in 2 ways:

i. Using Moisture value : If the Moisture value in the soil is less than a threshold/desired value (here, less than 30%). The STM32 will turn ON the motor till the value exceeds the desired value.

ii. Using ESP8266 webserver: When the user presses the on button on the server, the STM32 reads the high pin coming from ESP8266 and turns the motor ON until the user himself turns it OFF.

2. Working of ESP8266 :
    - The ESP8266 module creates the webserver where our sensor value and button will be displayed.
    - The values coming from the STM32 are read by the wifi module and then the sensor values i.e Temperature, Humidity and Moisture will be displayed on the webserver.
    - The ESP8266 wifi module sends a high or '1' through a pin to the STM32 to control the motor according to the state of the button
    - It also prints the status of the motor on the webserver as well as gives the user a warning if the Humidity and Temperature values are not within the desired range.

4.3. Result:

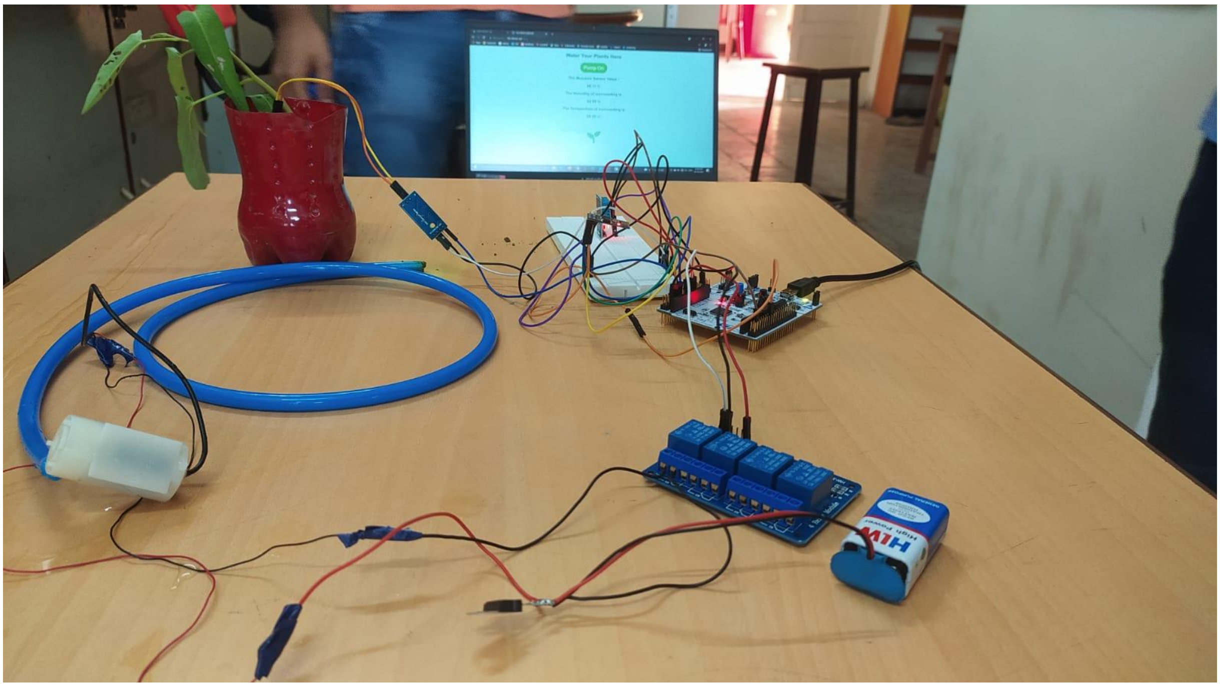

Fig 4.3.1

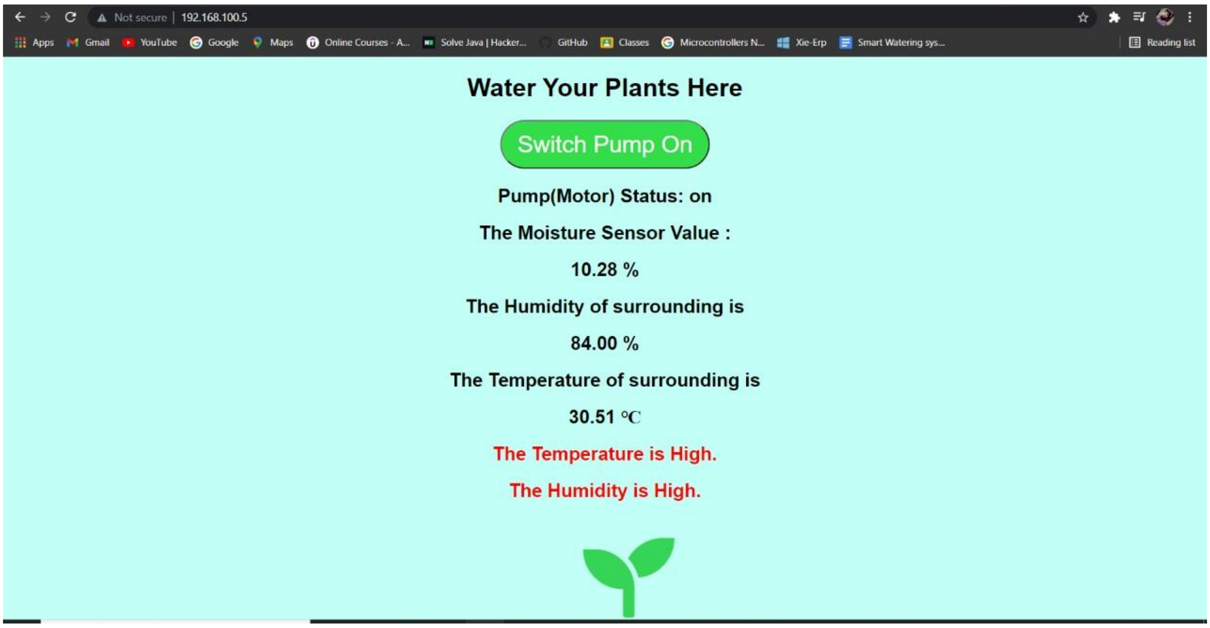

Fig.4.3.2

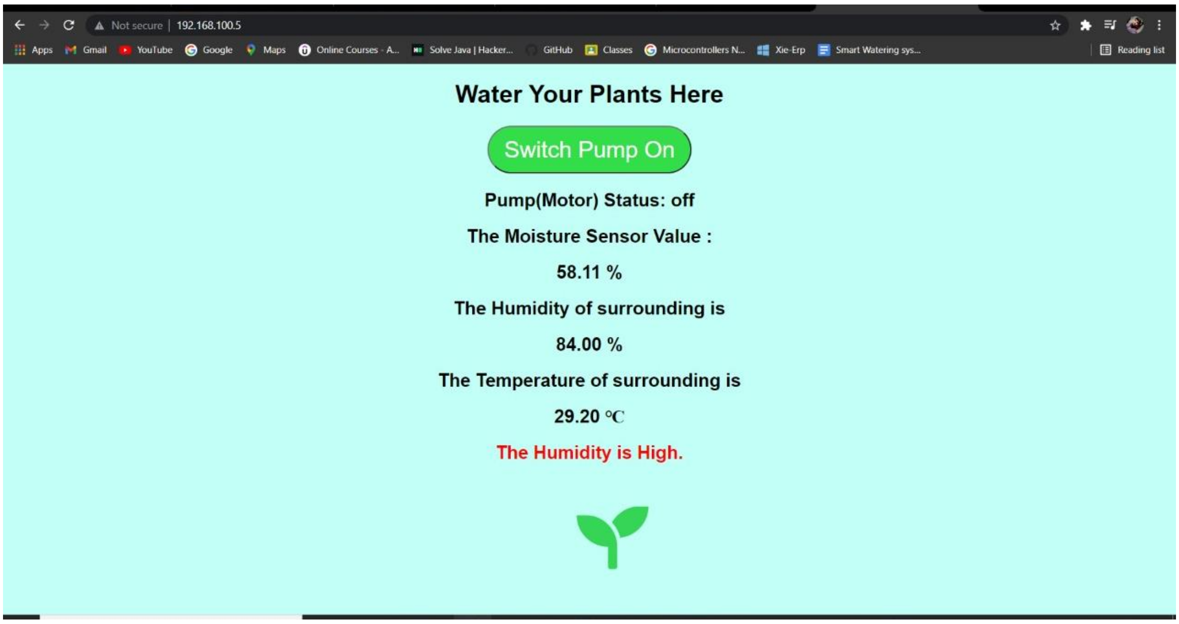

Fig 4.3.3

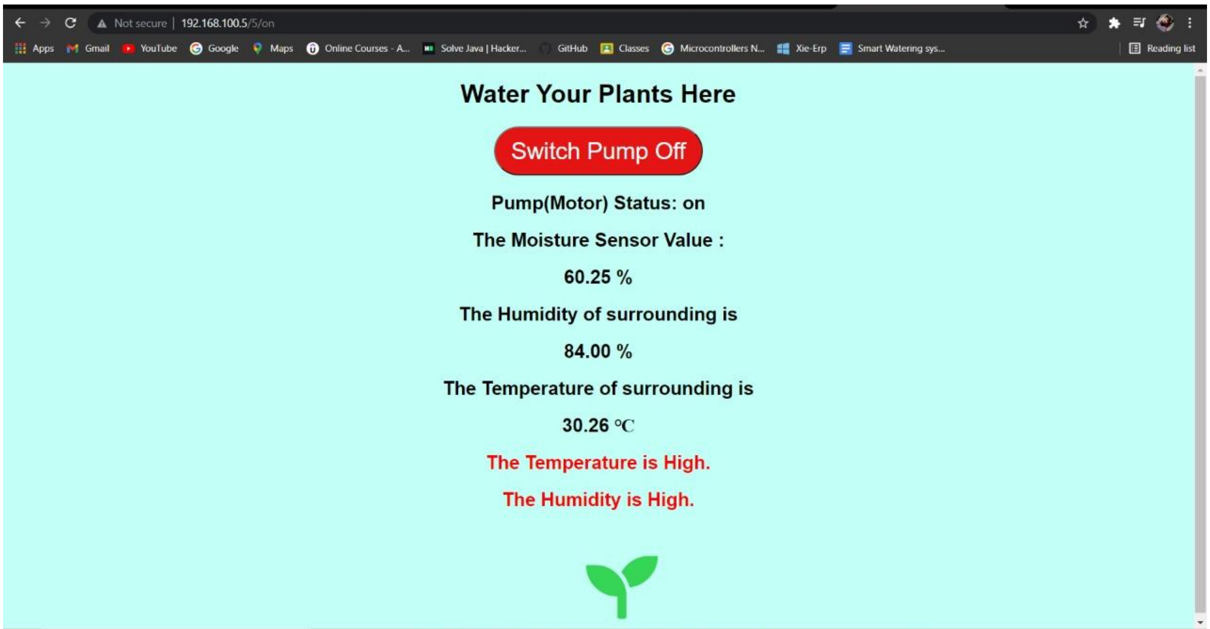

Fig 4.3.4

4.4.Applications:

1. It is very useful for the user to control the system remotely to water the plants without having to be physically present there.

2. It can be used in home-gardens to monitor the plant growth.

3. It can be further modified and made into an app where the user can check all the data gathered on the plants.

Chapter 5

5.1.Conclusion

In this report we gave an overview on how our project works and the different components used. We have designed a technique of monitoring and controlling the moisture level of soil. It allows the user to see and keep up with the values of dampness (moisture), humidity and the temperature remotely through a web server. It also allows the user to water the plants according to the sensor values displayed. Additionally, the pump also starts automatically when it goes below a certain level.

This project is very useful for remotely watering the plants without having to be physically present.The system senses the moisture content of the soil and automatically turns the pump on and off according to the water required. The system also gives a warning if the Humidity and Temperature values are not within the desired range which will be displayed on the web server. Thus, this project ensures wireless and user friendly operations and also prevents the wastage of water.

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