

Drip Irrigation and monitoring based on raspberry pi and arduino

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Abstract— Drip irrigation, is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants. This paper proposes a smart drip irrigation system which can be used to schedule drip irrigation based on raspberry pi and arduino. The scheduling can be done via a website which is hosted on the raspberry pi. Also scheduling can be done by sending email with a particular subject format to a particular email id. The water level in the tank used for drip irrigation is maintained by using a solenoid valve which is controlled by the arduino. This system can be used to monitor the temperature, relative humidity and moisture of the soil of the plants via different sensors controlled by arduino and they are sent to the raspberry pi via zigbee wireless protocol and they are plotted against time and shown on the website. This enables the user to schedule the drip irrigation based on the reported changes in temperature, humidity and moisture. This makes it a very effective drip irrigation system.

IndexTerms— drip irrigation; raspberry pi; python; flask; arduino,zigbee.

I. INTRODUCTION

This paper describes a smart drip irrigation system. Drip irrigation system makes the efficient use of water and fertilizer. Water is slowly dripped to the roots of the plants through narrow tubes and valves. Water is fed directly to the base of the plants which is a perfect way to water plants. There should be proper drainage in the fields or pot plants to avoid any water logging which in case may affect the productivity [1]. This paper presents a drip irrigation system to water and monitor plants with the use of devices like raspberry pi, Arduino microcontrollers. Xbee is used for the wireless communication between the raspberry pi and the arduino. Python programming language is used in the raspberry pi to communicate using xbee and for scheduling the automation. The website for scheduling is constructed using flask, mysql and python. This system once installed has no maintenance cost and is very easy to use. The sensor for temperature, humidity and moisture gives the user a real picture of the variation in these parameters via the different graphs on the website. Based on these values the user can decide the optimum time and duration for watering the plants.

II. MAIN COMPONENTS OF THE SYSTEM

The main components of the system are the raspberry pi, arduino and zigbee and the humidity and moisture sensors.

Central Component

Raspberry pi is a pocket personal computer with Linux operating system installed on it. This is super cheap to encourage young people for learning, programming, experimenting and innovation. Resembling like motherboard, raspberry pi has all the components to connect inputs, outputs and storage.

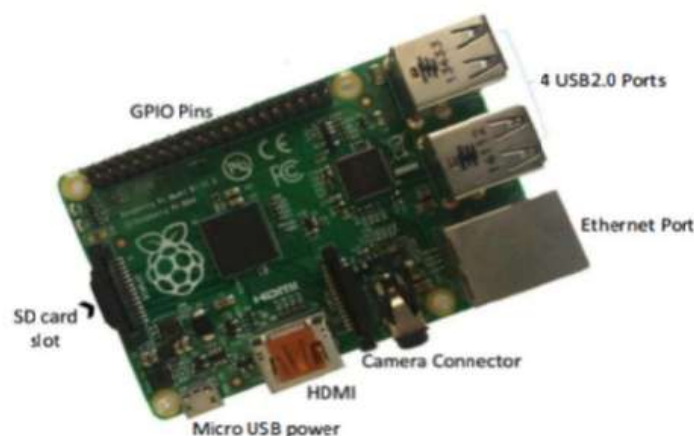


Fig 1 Raspberry PI board

Zig Bee Protocol

ZigBee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that require short-range low-rate wireless data transfer. Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics. ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit symmetric encryption keys.) ZigBee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device.

DHT11 Temperature and Humidity Sensor Module

This board is a breakout board for the DHT11 sensor and gives a digital output that is proportional to temperature and humidity measured by the sensor. Technology used to produce the DHT11 sensor grants high reliability, excellent long-term stability and very fast response time. Each DHT11 element is accurately calibrated in the laboratory. Calibration coefficient is stored in the internal OTP memory and this value is used by the sensor's internal signal detecting process. The single-wire serial interface makes the integration of this sensor in digital system quick and easy. Sensor physical interfacing is realized through a 0.1" pitch 3-pin connector: +5V, GND and DATA. First two pins are power supply and ground and they are used to power the sensor, the third one is the sensor digital output signal. Its small physical size (1.05"x0.7") and its very light weight (just 0.1oz) make this board an ideal choice to implementing small robots and ambient monitoring systems.



Fig 2 DHT11 temperature and humidity module

This module was used to collect the temperature and relative humidity by the audrino uno and send those to the raspberry pi by xbee and they are plotted against time and shown as graphs on the website

Soil Moisture Meter testing Module, Soil Humidity Sensor, Water Sensor, Soil Hygrometer Detection module for Arduino

- Operating voltage: 3.3V~5V; Dual output mode, analog output more accurate; A fixed bolt hole for easy installation . With power indicator (red) and digital switching output indicator (green); Having LM393 comparator chip, stable
- Panel PCB Dimension: Approx. 3cm x 1.5cm; Soil Probe Dimension: Approx. 6cm x 3cm; Cable Length: Approx. 21cm
- Interface Description(4-wire); VCC: 3.3V-5V; GND: GND
- DO: digital output interface(0 and 1); AO: analog output interface

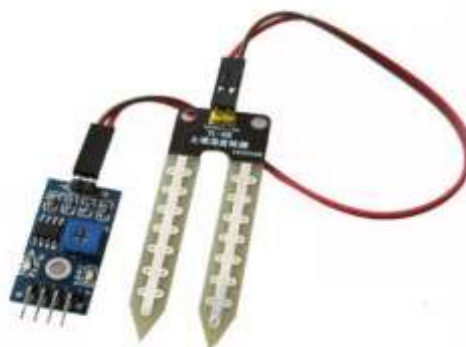


Fig 3 soil moisture sensor

This module was used to collect the moisture by the audrino uno and send those to the raspberry pi by xbee and they are plotted against time and shown as graphs on the website.

III. DESIGN OF THE SYSTEM

Complete block diagram of the system

The block diagram of the proposed automatic irrigation system is shown in Fig. 4. This is the block diagram proposed in reference [1]. In addition to these we have added website to schedule automation and sensors to get humidity, temperature and moisture information and plotted the variation of these on the website. The main components of the system are the raspberry pi, zigbee, arduino and the relays. The raspberry pi hosts the website for scheduling. It also runs the script to check the email account for mails for scheduling. This script checks the stop and starts times for scheduling and sends the particular code for start and stop at the corresponding times to the arduino via xbee. The xbee is connected to the usb port of the raspberry pi via an xbee adapter. The python script connects to the usb port and sends the required data using xbee. This data is received by the xbee at the arduino side. The raspberry pi also has the script to receive data from the xbee that is the moisture and humidity information and update that in the mysql table. The website plots this data against time and show different plots. The sensors are connected to the arduino via the ports and the required data is send to the raspberry pi. Arduino also checks the height of the water in the tank and controls the solenoid valve and maintains the water level in the tank. Arduino also controls the relay for switching ON and OFF the motor for drip irrigation based on the commands sent from the raspberry pi.

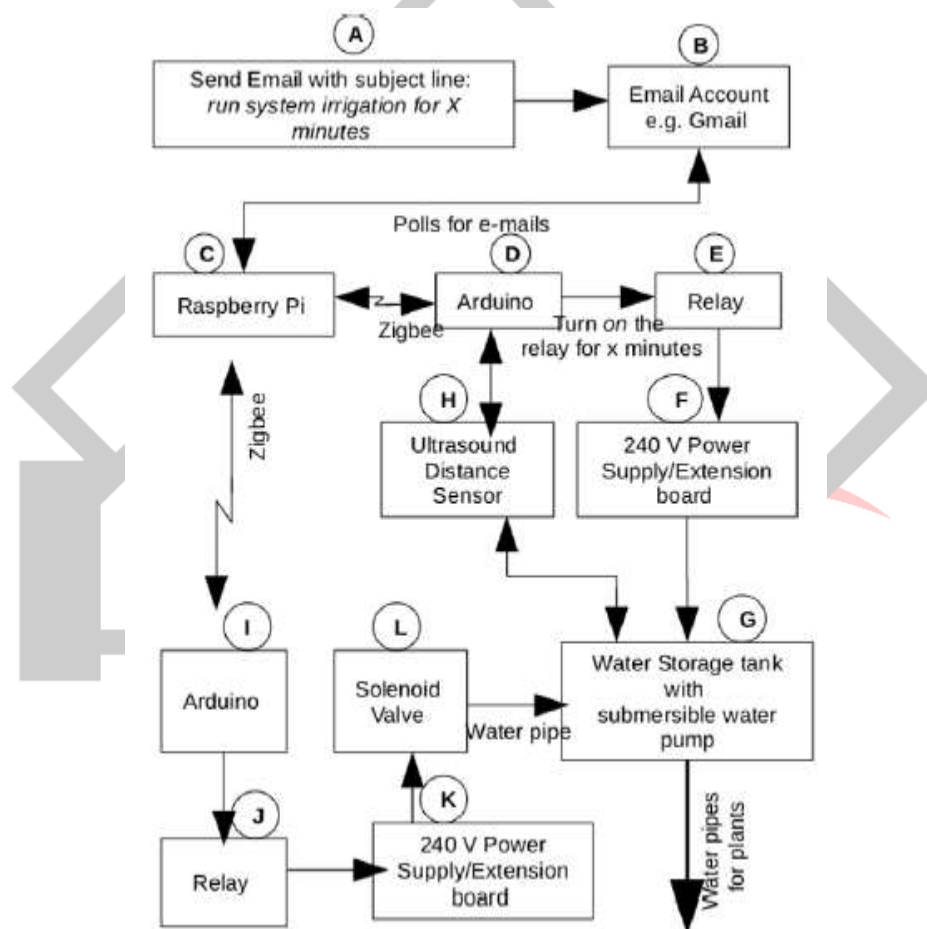


Fig 4 Block Diagram of proposed system^[1]

The meaning and functionality of each block with respect to the labels mentioned in the figure is as follows:

A. Send Email: To start the drip irrigation system an email is sent to a defined account having subject line : “run irrigation system for X minutes”. For example in Fig. 4, to run irrigation system for two minutes, an email with the subject line is sent “S1 ON START 23:18 STOP 23:20”

B. Email Account: Raspberry pi will poll for emails in this email account. Google email account is used in this paper.

C. Raspberry Pi: Model B of Raspberry is used in this paper. As soon as the email is received, one of the GPIO is turned high. A program written in Python programming language has been used to receive email and turning a GPIO pin high for the requested duration. The same program also sends the status updates to user's email address.

Software libraries used in Python programming are:

- SMTP library to send status email
- IMAP library for email polling
- BCM for GPIO control in raspberry pi.

Pi also sends and receives commands from and to the arduino microcontrollers using the zigbee modules. Programming is done for both pi and arduino using python and arduino core functions and libraries respectively for proper communication via zigbee. Figure 4 explains the communication circuitry between the raspberry pi and zigbee module. It is shown that pi uses USB to TTL converter to talk to the zigbee module.

D. Arduino: It is an open source microcontroller which is used to control relay and ultrasound distance sensor. Arduino libraries and functions are used in the program (not shown). In case a low water level is detected by the sensor (part H) then a signal will be sent from the microcontroller to pi. Pi will replay the same signal to arduino (part I) and solenoid valve (part L) will be turned on via relay.

In addition to the above we have the temperature/humidity and moisture sensors connected to the arduino. We have a website to schedule and monitor the drip irrigation.

The below is the overall design of the website and python script at the raspberry pi side of the system. The flask webserver runs the website which can be used to schedule the drip irrigation and for seeing the graphs related to temperature, humidity and moisture.

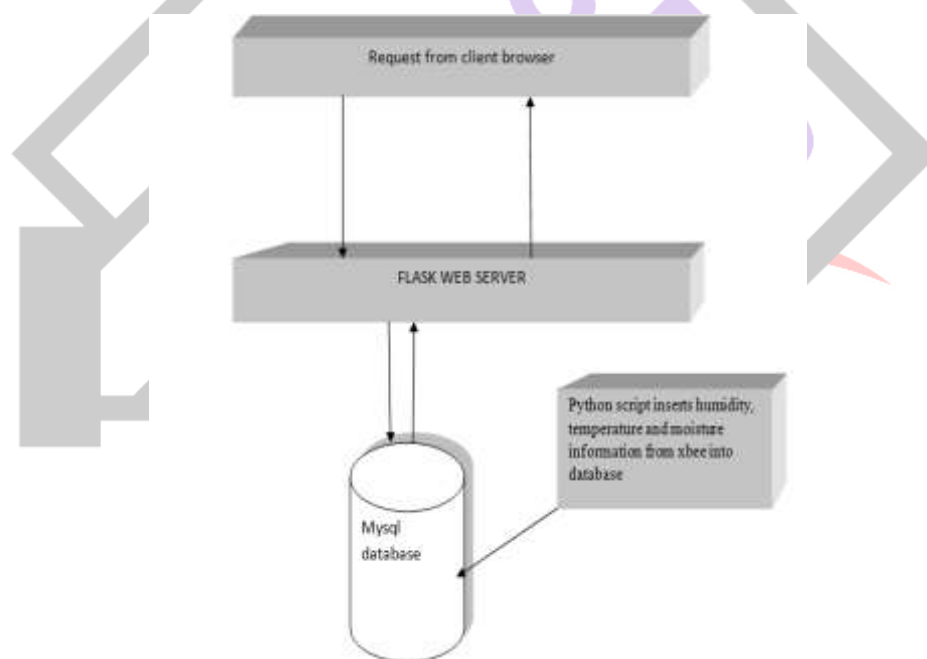


Fig 5 The flowchart for different components on the raspberry pi

The python script which checks whether an email is there to schedule the drip Irrigation follows the below steps. It connects to the serial port to communicate with xbee and via internet it makes an IMAP SSL connection to login to the gmail account using username and password. Then it checks the email gets the START and stop times and if the current time is the start time it send the start code to the audrino via the xbee. If the current time is equal to the stop time it sends the STOP code via the xbee.

The below diagram shows the flow of the python script which runs in raspberry pi

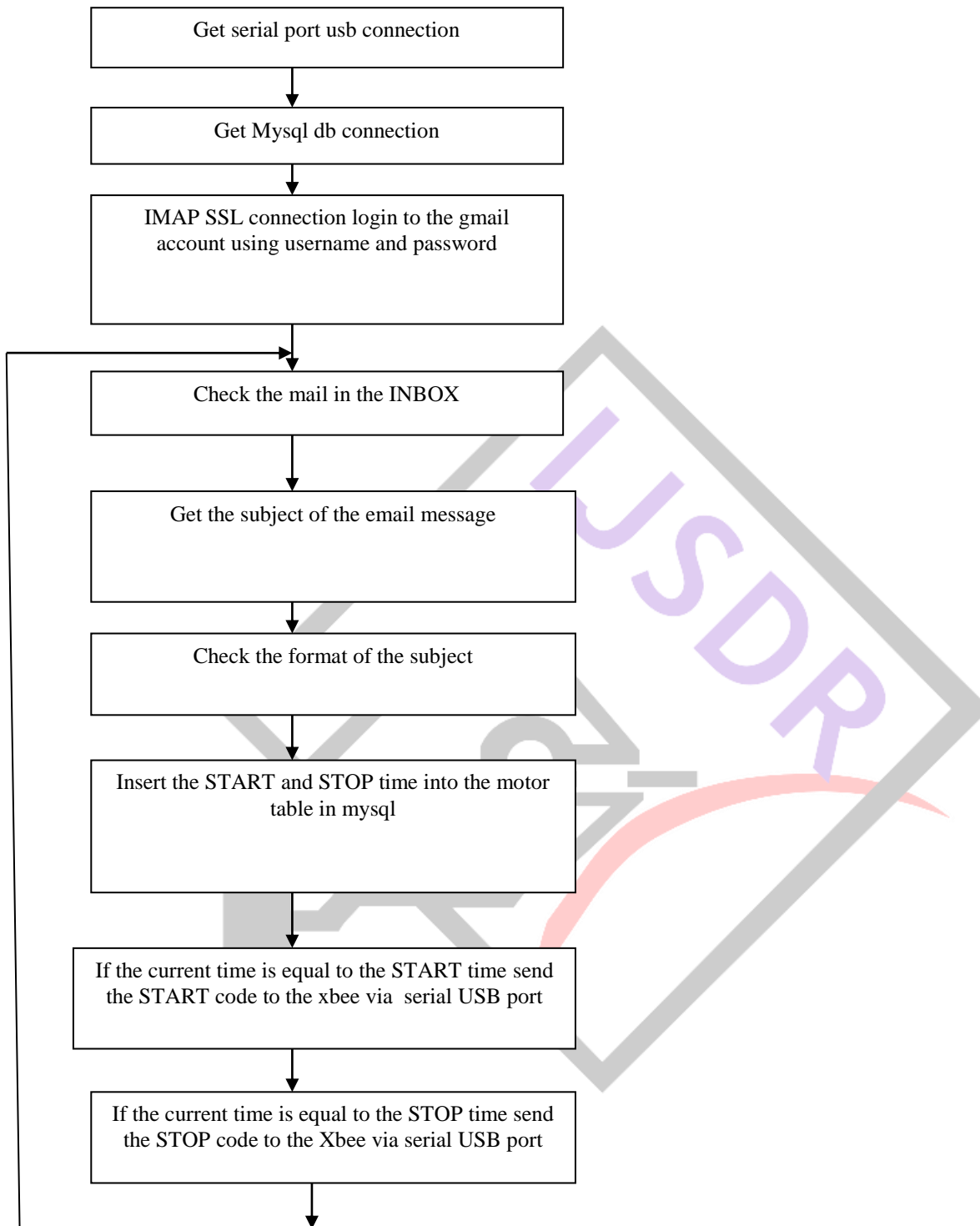


Fig 6 Flow of code in python script to check schedule of drip irrigation

The follow of the code in the arduino side is as follows below

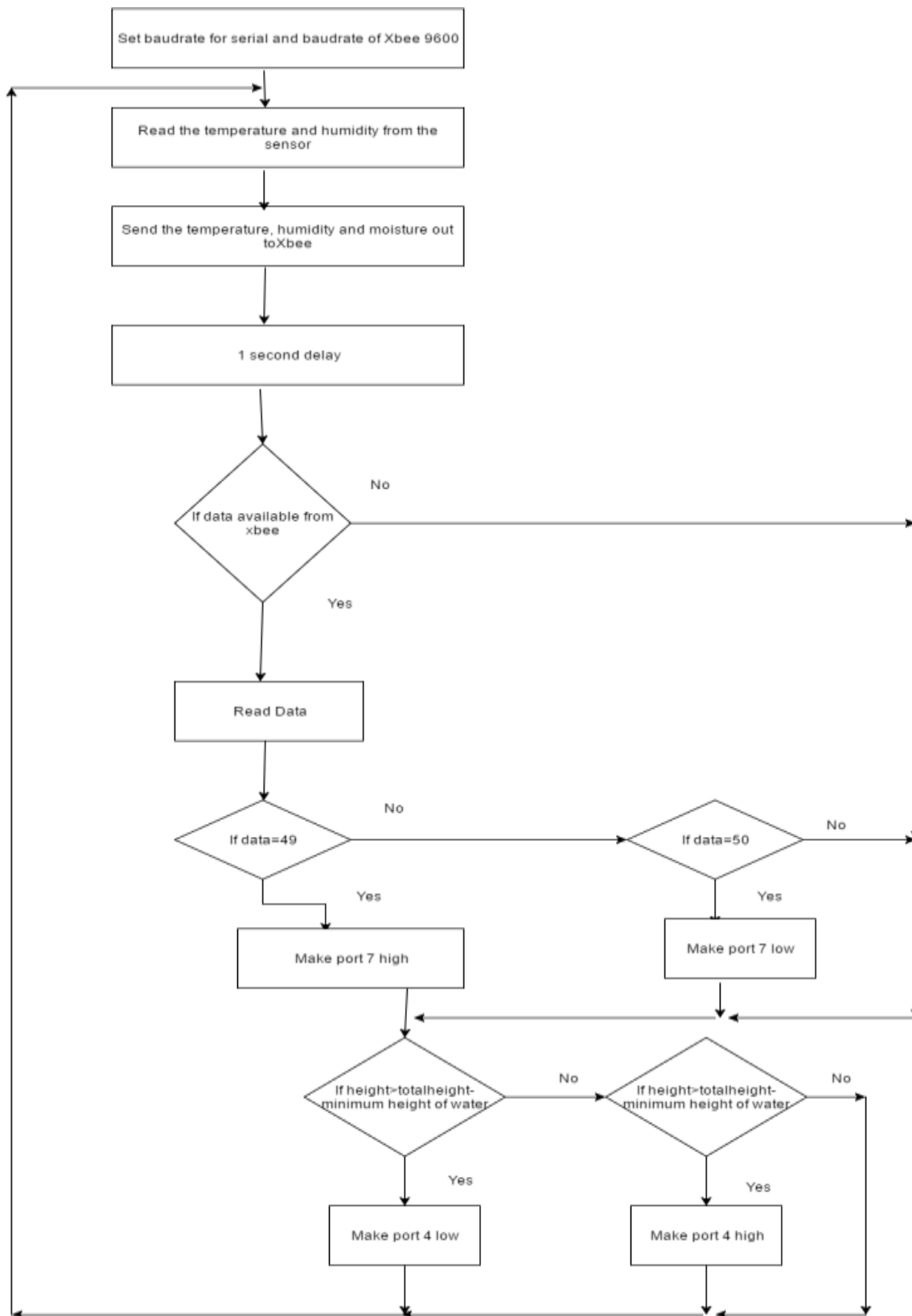


Fig 7 Flow chart of arduino code

IV. TOOLS AND LANGUAGES USED

The tools used in this project include Flask , MySQL and the languages used are Python and C/C++

Flask (web Framework)

Flask is a micro web application framework written in Python and based on the Werkzeug toolkit and Jinja2 template engine. It is BSD licensed. As of 2015, the latest stable version of Flask is 0.10.1. Flask is called a micro framework because it does not presume or force a developer to use a particular tool or library. It has no database abstraction layer, form validation, or any other components where pre-existing third-party libraries provide common functions. However, Flask supports extensions that can add application features as if they were implemented in Flask itself. Extensions exist for object-relational mappers, form validation, upload handling, various open authentication technologies and several common framework related tools.

Mysql

MySQL is an open-source relational database management system (RDBMS); in July 2013, it was the world's second most widely used RDBMS, and the most widely used open-source client-server model RDBMS. The MySQL development project has made its source code available under the terms of the GNU General Public License, as well as under a variety of proprietary agreements. MySQL was owned and sponsored by a single for-profit firm, the Swedish company MySQL AB, now owned by Oracle Corporation. For proprietary use, several paid editions are available, and offer additional functionality.

Python

Python is a widely used general-purpose, high-level programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java. The language provides constructs intended to enable clear programs on both a small and large scale. Python supports multiple programming paradigms, including object-oriented, imperative and functional programming or procedural styles. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library. Python interpreters are available for installation on many operating systems, allowing Python code execution on a wide variety of systems. Using third-party tools, such as Py2exe or Pyinstaller, Python code can be packaged into stand-alone executable programs for some of the most popular operating systems, allowing the distribution of Python-based software for use on those environments without requiring the installation of a Python interpreter.

X-CTU

The X-CTU software is free to download and provides a simple interface to configure and update your XBee transceivers. With this software firmware updates are a breeze and configuration is simple. The software can be downloaded from Digi's website.

ARDUINO 1.6.8

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.

V. RESULTS

For automating the drip irrigation system the user can login to a website and then schedule the duration for which irrigation motor should be switched on. The website configures a mail with subject line in prescribed format and sends it to the configured mail ID. The Raspberry Pi continuously monitors the configured mail ID for new mails and analyses the subject of the mail if it is in the prescribed format. The start time and end time for switching the motor on and off are determined. Also the the follow into the tank used for drip irrigation is automated. When the level in the tank drops below a specific level the relay turns on and the solenoid valve allows water to flow into the tank from the main supply.

Drip Irrigation Automation Home page

User can access the Drip Irrigation Automation Website via this home page.

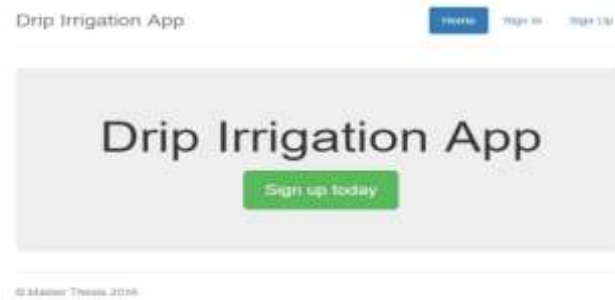


Fig 8 Drip Irrigation Automation Home Page

Drip Irrigation Automation Login page

Authorized users can access the Drip Irrigation Automation webpage by logging in using username and password. User's credentials will be verified from the MySQL database. If the user is an authorized person he will be allowed to login and will be redirected to the page where he can schedule his automation.

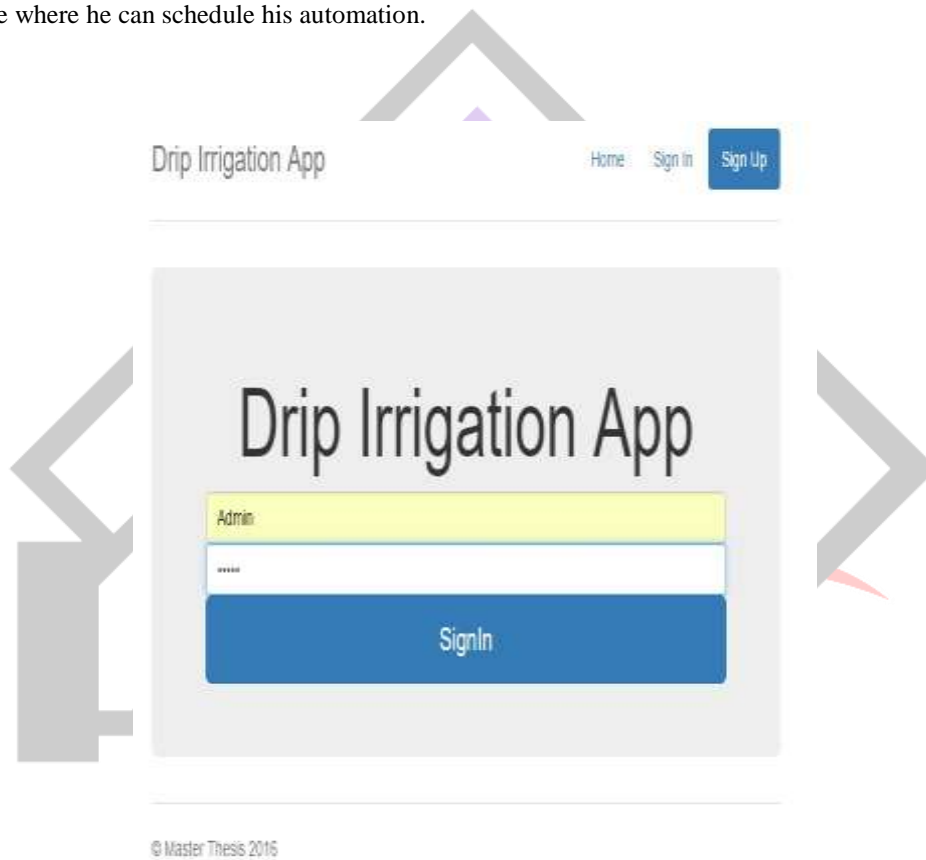


Fig 9 Drip Irrigation Automation Login Page

Drip Irrigation Automation Scheduling page

An authorized user can schedule the automation by choosing the start time and stop time for switching ON and OFF the motor. Once the time is chosen from the drop down menu and submitted, the webserver frames an email with subject line in the prescribed format. This email will be sent to the configured Gmail ID. If no network problems exist, a display saying "mail sent successfully" will be shown. This page also shows the current schedule time of the motor.



Fig 10 Drip Irrigation Automation Scheduling Page

Once the mail is send successfully, a message will be displayed on the screen to indicate the same to the user.



Fig 11 Drip Irrigation temperature, humidity and moisture graphs

The above screen shot shows the variation in temperature, relative humidity and moisture with time. These are plotted with the information sent from the corresponding sensors connected to arduino which is then sent to raspberry pi via zigbee and are stored in a table in the raspberry pi. Seeing the variation in these parameters the user can decide the best schedule for the drip irrigation.

VI. CONCLUSION

This smart drip irrigation system will prove to be a useful system as it automates and regulates the watering without any manual intervention. In addition to email scheduling it provides a website which shows the current schedule for drip irrigation and provides facility to change this schedule. This system automates Drip Irrigation on a predefined schedule and flow of water into the main tank as and when required. The graphs provide information about the temperature, humidity and the moisture content experienced by the plants and correspondingly we can decide when and how to water the plants. The limitation of this design is that the failure of any particular part or device is not informed and has to be tested manually.

REFERENCES

- [1] Nikhil Agrawal, Smita Singhal "Smart Drip Irrigation System using Raspberry pi and Arduino" International Conference on Computing, Communication and Automation (ICCCA2015)
- [2] <http://www.fao.org/docrep/s8684e/s8684e07.htm#6.1> when to use drip irrigation
- [3] https://en.wikipedia.org/wiki/Drip_irrigation
- [4] R.Hussain, J.Sehgal, A.Gangwar, M.Riyag "Control of irrigation automatically by using wireless sensor network" International journal of soft computing and engineering, vol.3, issue 1, march 2013, pp.48t 324-328
- [5] Nilesh R. Patel, Swarup S. Mathurkar "Microcontroller Based Drip Irrigation system using Smart Sensor" 2013 Annual IEEE India Conference (INDICON)
- [6] A Gaddam, M Al-Hrooby, W F Esmael "Designing a Wireless Sensors Network for Monitoring and Predicting Droughts" 8th International Conference on Sensing Technology, Sep. 2-4, 2014, Liverpool, UK
- [7] S.Pushpavel, P.Saravanan "RaspberryPi using IR Thermal Camera in Agriculture Farm for Smart Irrigation System" International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 08 | Nov-2015
- [8] Sandeep Nallani, V. Berlin Hency "Low Power Cost Effective Automatic Irrigation System" Indian Journal of Science and Technology, Vol 8(23), DOI: 10.17485/ijst/2015/v8i23/79973, September 2015