Palestine Polytechnic University
College of IT and Computer Engineering
Department of Computer Engineering

Graduation Project
Smart plant pot

Project Team

Ola Kurdeya

Hadeel Salamin

Israa Bet-rashed

Project Supervisor
Mr-Elayan Abu Gharbyeh

Hebron-Palestine

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Dedication

This project is dedicated to our families, parents and friends that have been a strong and a steadfast support in our journey, they taught us the value of life and faithful love. Most of all we can't fully express in words for priceless love and encouragement they brought in our life.

Acknowledgements

At the beginning we thank Allah for giving us the ability to complete this project despite all the difficulties and challenges that we faced during the year.

We would like to thank our supervisor Eng.Elayan Abu Garbeyeh who stood with us and was generous enough to give us the support we needed to complete this project successfully.

We also thank all the instructors in college of IT and Computer Engineering for their great effort and support during all these years.

We must not forget to acknowledge Palestine Polytechnic University for giving us this great opportunity and for embracing us during these 5 years.

We also thank the deanship of graduate studies and scientific research of funding our project with 400 JD, and for supporting us continuously.

Abstract

The system proposed in this project is 'Smart Plant Pots' which is a tri-sensor technology to provide automatic watering, cooling and sunlight for houseplants to maintain them.

System components used are Humidity and temperature sensor, soil moisture sensor, LDR sensor, Transistor switches, relay nodes for automatic control, alarm for warning the user for some cases, LCD to show the status of the plant and Arduino Uno to control the plant pot information. This system develops a wireless sensor network using XBee technology to link the whole parts of the system together so they can interact with each other. The testing of this system divided into number of subsystems. We test each subsystem individually then connect all subsystems together to get the final circuit. As the result of this project, we design a successful fully automated system for houseplant care. This system monitors and controls all parameters needed to maintain the houseplants.

For future developing, we can connect our system with a database provided on the internet so that any update on the internet database will be updated to our system synchronously. Also t can be expanded to many pots for the same system.

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Chapter 1

Introduction

1.1 Project Overview

Most people would love to have nice Ornamental plants inside their houses, but few have the time to maintain them. Above all, plants require most important factors for the quality of plant growth are temperature, humidity and light. With Continuous monitoring of these environmental variables you can keep your houseplants perfect.

Our system will be designed to monitor and record the values of temperature; soil moisture and light of the natural environment that are continuously modified and controlled in order to optimize them to achieve maximum plant growth and yield.

1.2 Chapter Overview

In this chapter, we will describe the idea of our smart plant pots system, its features, objectives and functions that it performs. Also, we will explain the reasons and motivations why we choose this project.

1.3 Description Of The System

The proposed system is an embedded system which will monitor and control the important parameter of the houseplants (temperature, soil moisture and light). Using three commercial sensors in the plant pot, the system become capable to measure three climate variables.

When any of the above mentioned climatic parameters cross safety threshold which has to be maintained to protect the plants, the sensors sense the changes and transmit them wirelessly to the microcontroller using XBee technology which is one of the easiest ways to create a wireless point-to-point or mesh network. The microcontroller receives this signal after being converted to a digital form .Then performs the needed actions which can be supplying the plant with water, lighting, or change the ambient temperature, by utilizing relays until the strayed-out parameter has been brought back to its optimum level. The system also employs an LCD display for continuously alerting the user about the condition in its garden.

1.4 Motivations

We choose this project to make garden and houseplants care easier and handle it in most efficient way also to insure a safe environment for the plant, and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent. This technology really could have benefits for people who love to have beautiful garden inside their houses but not have a time and ability to maintain it.

1.5 Objectives

The objectives of this project are to design a simple, easy to install, microcontroller-based circuit to monitor houseplants. It communicates with the various sensor modules in real-time in order to control the important parameter by actuating the internal water pump, mini air conditioner and artificial lights respectively according to the necessary condition of the plants. Communication will be wirelessly to make the system expandable in the future.
An integrated Liquid crystal display (LCD) will be used for display the status of the plant depends on the data that acquired from the various sensors.

1.6 Overview Of Next Chapters

Chapter Two: This chapter analyzes the system in more details, talks also about system requirements and expected results .

Chapter Three: This chapter talks about the theoretical background of smart plant pots; we also consider the related project and papers and compare them with our system. It also contains a description of the parts and components used in the system.

Chapter Four: This chapter describes the module for the system to satisfy specified requirements. It also contains a description of the component use in the system and why they are chosen and how components are connected together. Also contains block diagrams, schematic diagram, and any necessary information about the design.

Chapter Five: This chapter defines the software component used to control our system in addition to explain how we configured our XBee modules to satisfy specific requirements.

Chapter Six: This chapter shows and explains the implementation of the system, implementation challenges that we faced and the implementation of integrated system. In addition it presents the test of each subsystem and the results we obtained.

Chapter seven: This chapter considers all conclusions of the project, in addition to future works that can be developed on the system.

Chapter 2

Problem Statement

2.1 Chapter Overview

In this chapter, we will describe and analyze the system in more details; we will also talk about system requirements and expected results.

2.2 Problem Analysis

Many people like to have house gardens or even houseplants inside their houses, especially in living room and at the house corners. But taking care of the plants is time consuming and needs effort. Although some people strongly take care of their plants, they complain from that plants keep dying or growing slowly.

Plants growing depend on many parameters that may be different from plant to another. And those parameters are hard to be sensed by human.

Our plant care system consists of highly sensitive sensors, which measure all the parameters needed to maintain any specific plant in high accuracy. The user only needs to turn on the system that will automatically provide the suitable environment for the plant. The system gives a warning to the user when the water ends from the tank inside the plant pot, by placing a water level sensor inside the water tank and connects it with alarm and led they work when the water reaches to the lowest level.

So the system overcomes the problem of sensing the situation surrounding the plant and saving the efforts and time of the user as this system is fully automated.

There is several measurement points are required to trace down the local parameters in different plant pots to make the automation system work properly so cabling would make this system expensive and vulnerable. Moreover the cable measurement points are difficult to relocate once they are installed. Thus, a wireless sensor network by using XBee technology is flexible and cost efficient option to build the required measurement system.

2.3 List Of Requirements

System requirements can be summarized as:

1. The system must provide integrated care for houseplants.
2. Senses the change on plant environmental variables (temperature, soil moisture and light) using several sensors.
3. Determines the desired action by microcontroller depending on the signals from the sensors.
4. Turn on or off the controlled devices which are water tank with pump, cooler and artificial light based on the signals from microcontroller.
5. Gives a warning to the user when the water ends from the tank inside the plant pot.
6. Displays the status of the plants on LCD.
7. The software must be able to communicate with microcontroller and other devices.
8. The system must be able to expand in the future. So user can connect more than one pot on the same microcontroller.

Chapter 3

Background

3.1 Chapter Overview

This chapter describes the theoretical background of smart plant pots; it also reviews related projects and work and compares them with our system. It also contains a description of the main parts and hardware components we want to use them in the system and why they are chosen.

3.2 Theoretical Background

Plants sense the natural shortening of daylight hours and may go dormant as they would in their natural habitat. While plants are dormant they should receive a minimum amount of water at any time that the soil becomes dry an inch below the surface.

Proper lighting and watering are the most important criteria for the health of your house plant, while temperature and humidity are less important; but that does not prevent the temperature and humidity from drastically affecting your plants health as well.

House plants enjoy a relative humidity of (50-70)% and warm temperature. Unfortunately, when temperatures in the home rise above 67 Fahrenheit which equal 19.44 Celsius, the humidity drops drastically, so it may be necessary to sacrifice a few degrees of warmth in lieu of an increase in the humidity[1]

3.3 Literature Review

There are several studies worked on similar problems and proposed some situations. Below are descriptions of those studies.

1. **Digitally Greenhouse Monitoring and Controlling Of System Based On Embedded System** [2]

   This project is an embedded system which will closely monitor and control the parameters of a greenhouse on a regular microclimatic basis round the clock for cultivation of crops or specific plant species which could maximize their production over the whole crop growth season. Our project is different such that it is a simple, easy to install, microcontroller-based circuit to monitor the Ornamental plants inside houses.

2. **Greenhouse Monitoring With Wireless Sensor Network** [3]

   This project developed a wireless sensor node for greenhouse monitoring by integrating a sensor platform provided by Sensinode Ltd. with three commercial sensors capable to measure four climate variables. Wireless sensor network (WSN) can form a useful part of the automation system architecture in modern greenhouses.

   Wireless communication can be used to collect the measurements and to communicate between the centralized control and the actuators located to the different parts of the greenhouse.

   In our project XBee communication is be used instead of wireless sensor node for reducing costs and complexity.

3. **High-Tech Flower Pot Automatically Waters And Fertilizers The Plant** [4]

   The Click and Grow allows urban dwellers to maintain an indoor garden with minimum effort. Although having an indoor herb garden always sounds like a great idea, maintaining the plants can prove to be difficult, especially if you lead a hectic schedule. Now there's a gadget for the busy green thumb that can grow and sustain the plant without much human interaction. Click and Grow is an electronic flowerpot that automatically gives the necessary amount of water, fertilizer, and air, according to the plant's needs.

The smart flowerpot is battery-powered and comes with a replaceable 'plant cartridge' that holds the seeds, nutrients and the software. All the user needs to do is fill the pot with one liter of water, and ensure the plant is placed in a spot with plenty of sunlight throughout the day.

In our project we provide artificial light as alternative of sunlight so the user does not need to place its plant pot in a spot with sunlight. Also our system controls its devices automatically by itself and does not need the user to click a button to start any operation.

3.4 Main Parts Of Smart Plant Pots System

Figure(3.1)shows the high level architecture of the system and the relationship between parts.

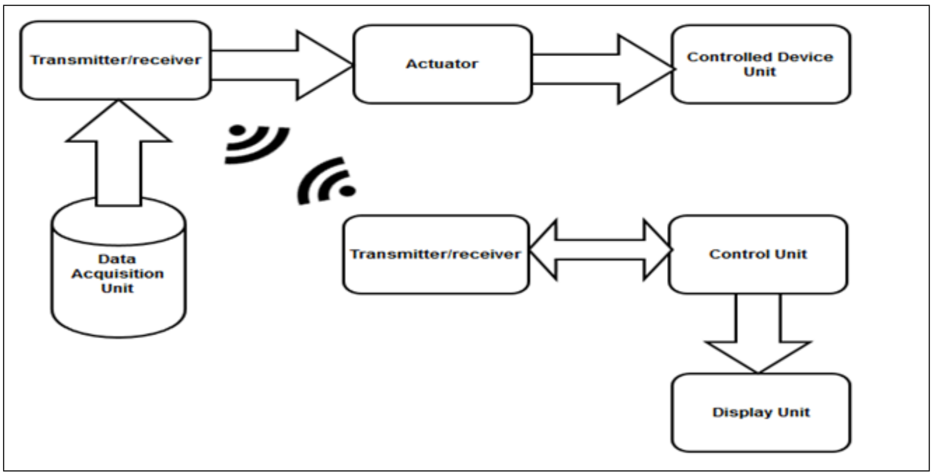

Figure 3.1: Main parts of smart plant pot system.

3.4.1 Data Acquisition Unit

Is a device that contains three sensors to measure and transform the data. This can be read by an observer.

- LDR-Light Dependent Resistor

LDR sensor used to measure intensity of light; the sensor is useful in light/dark circuit conditions. LDR device has a resistance that varies according to the intensity of light falling on its surface as shown in Figure(3.2) [5].

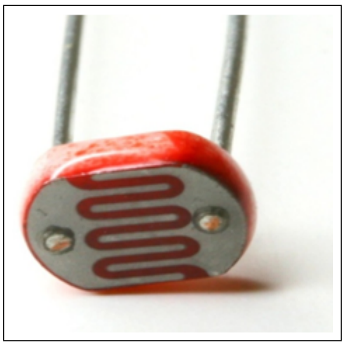

Figure 3.2: LDR-Light Dependent Resistor [6].

- LM35 temperature sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling [6] .

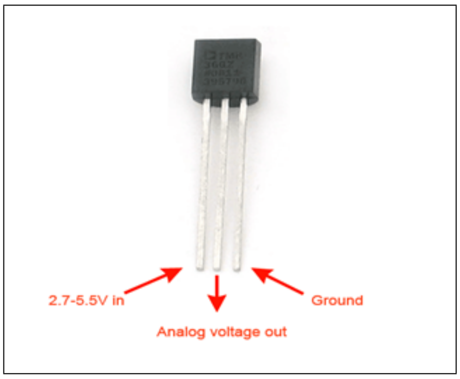

Figure 3.3: LM35 temperature sensor [6].

- Soil Moisture Sensor

This sensor can be used to detect the moisture of soil or judge if there is water around the sensor. Fig3.4 shows the soil moisture sensor [7].

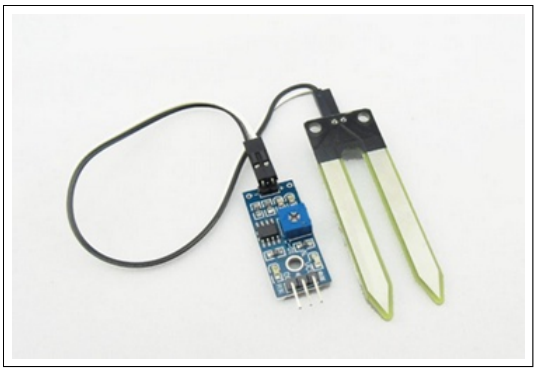

Figure 3.4: Soil Moisture Sensor.

3.4.2 Control unit (Microcontroller):

The microcontroller is the heart of the proposed embedded system. It constantly monitors the digitized parameters of the various sensors and verifies them with the predefined threshold values described in section 3.2. It checks if any corrective action should be taken for the condition at instant time. If this situation arises, the controller activates the actuators to perform a controlled operation.

3.4.2.1 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328 .It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter [7].The structure of Arduino Uno shows in Figure(3.5).

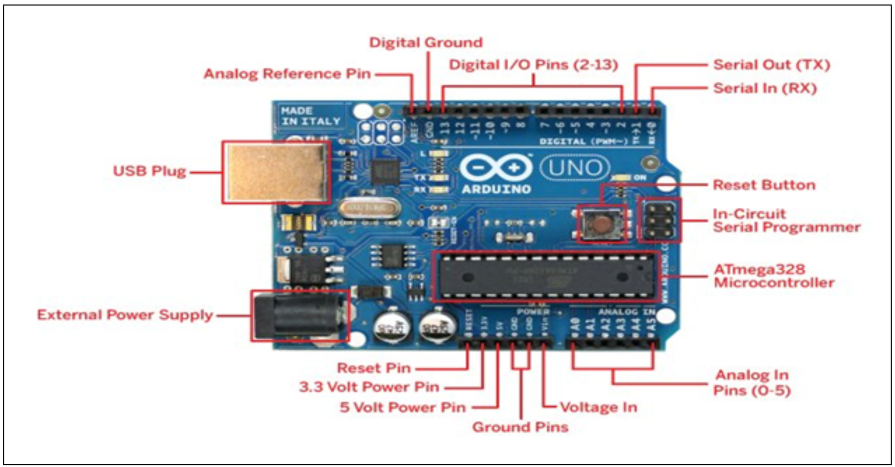

Figure 3.5: Arduino Uno microcontroller

3.4.3 Controlled devices unit

Devices perform the needed actions in response to signals from the microcontroller.

3.4.3.1 Pump

A pump can be used to take reserved water, increase the pressure, and deliver the water to your plants via a hosepipe . The pump that will be used is shown in figure(3.6)

Figure 3.6: water pump

3.4.3.2 Fan

Fans and air coolers should be used to maintain plant health during warm summer months.

3.4.3.3 Artificial Light

Since sunlight does not reach all areas in the house such as, we need to use alternative source for providing light to our houseplants. We can achieve this by using artificial lights.

3.4.4 Relay:

It is an electrical switch that opens and closes under the control of another electrical circuit. In the original form; the switch is operated by an Electromagnet field to open or close one or many sets of contacts [10].

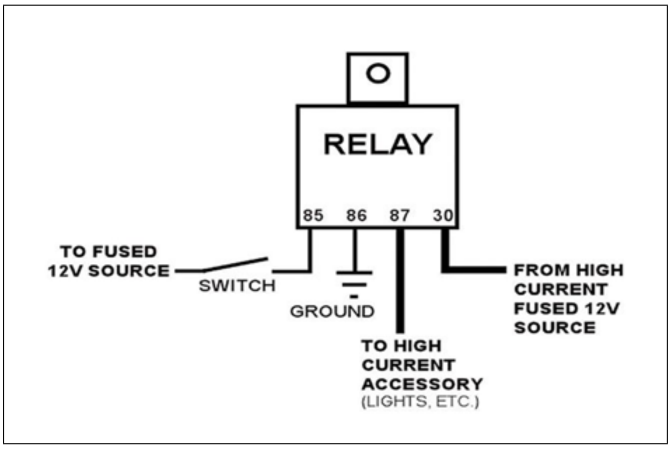

Figure 3.7: Relay pins

3.4.5 The Transceiver Unit

It provides communication medium between sensors, devices, and micro-controller.

3.4.5.1 XBee Modules:

The XBee XB24-Z7WIT-004 module from Digi. Series 2 improves on the power output and data protocol. Series 2 modules allow you to create complex mesh networks based on the XBee ZB ZigBee mesh firmware. These modules allow a very reliable and simple communication between microcontrollers, computers, systems, really anything with a serial port! Point to point and multi-point networks are supported [11].

Figure 3.8: XBee modules

XBee Features

- 3.3V @ 40mA
- 250kbps Max data rate
- 2mW output (+3dBm)
- 400ft (120m) range
- Built-in antenna
- Fully FCC certified
- 6 10-bit ADC input pins
- 8 digital IO pins
- 128-bit encryption
- Local or over-air configuration
- AT or API command set

3.4.6 Display Unit

It used to display data acquired from the various sensors and the status of the various devices. It serves as interface the system and the user.

3.4.6.1 LCD:

LCDs are a fun and easy way to have your microcontroller project talk back to you. Character LCDs are common, and easy to get, available in tons of colors and sizes, but the number of pins necessary to control the LCD can be restrictive, especially with ambitious projects.
By using simple i2c and SPI input/output expanders we have reduced the number of pins (only 2 pins are needed for i2c) while still making it easy to interface with the LCD [12].

Figure 3.9: LCD and I2C

3.5 Specification and Design Constrains:

3.5.1 Strengths:

1. Regarding to the implementation, Arduino programming is easy concept to deal with.
2. Using of XBee module makes the system easily expandable for large number of smart plant pots that controlled with only one microcontroller. Also the use of XBee module provides the system more reality such as the system does not restrict the user in placing the pots at specific places so those smart plant pots could be placed anywhere.
3. The simple plant pot self watering system saves the use of water since water is only released as the plant needs it.
4. Ideal for holidays, vacations and hot weather.

5. The high sensitive sensors used in this system give more accuracy in the measured values and that enhances plant health.

6. Grow plant with zero effort as the system is fully automated, it does not need any human attention or interaction.

7. The system gives your plant a face! Expressing of faces on the LCD displays exactly how the plant is feeling and what it needs from the user.

8. There is high separation of duties as the system allows the ordering and receiving functions to be performed by different operators.

3.5.2 Weaknesses

Each single smart plant pot will be added to the network system that will increase the cost badly, because each smart plant pot demands its own hardware components, except the microcontroller as it the only shared component in this system. Another thing would affect the cost that's the need to be careful with this system since the tools we are dealing with are very sensitive.

Chapter 4

Design [Options]

4.1 Chapter overview

In this chapter we will define the hardware components, modules, interface and other data for the system to satisfy specific requirements.

4.2 A brief description of the components of the system

Smart plant pots system will be designed to measure the values of soil moisture, light and temperature. In order to control these values according to the standard conditions to each plant. This system develops a wireless sensor network using XBee module (2mw chip antenna).

Several sensors will be used in our system which are, LDR, humidity and temperature LM35, and soil moisture sensors. They will be used inside the plant pot in order to measure three parameters that are mentioned above. These three sensors are connected with the XBee chip, which has 4 analog input pins. The XBee chip receives data from sensors and send them to other chip that is connected with the Arduino Uno microcontroller, this chip converts data from analog to digital so that the controller can read it and understand it, then the microcontroller compares this data with the required values and performs the needed actions by employing one or more control devices which are water pump, cooler and artificial light.

Various control devices inside the plant pot will also be connected with the XBee chip that receives the required actions from microcontroller and performs them according to values that come from sensors until the strayed-out parameter is brought back to its optimum level.

If the value of soil moisture exceeds the required value, the microcontroller employs the water pump, and delivers the water to plants via a hosepipe. The same operation will be done for light and temperature values.

LCD will be connected with the Arduino, its used to display the status of the plant depends on the data acquired from the various sensors.
The following diagram Figure(4.1) shows the general block diagram and how the components are connected together.

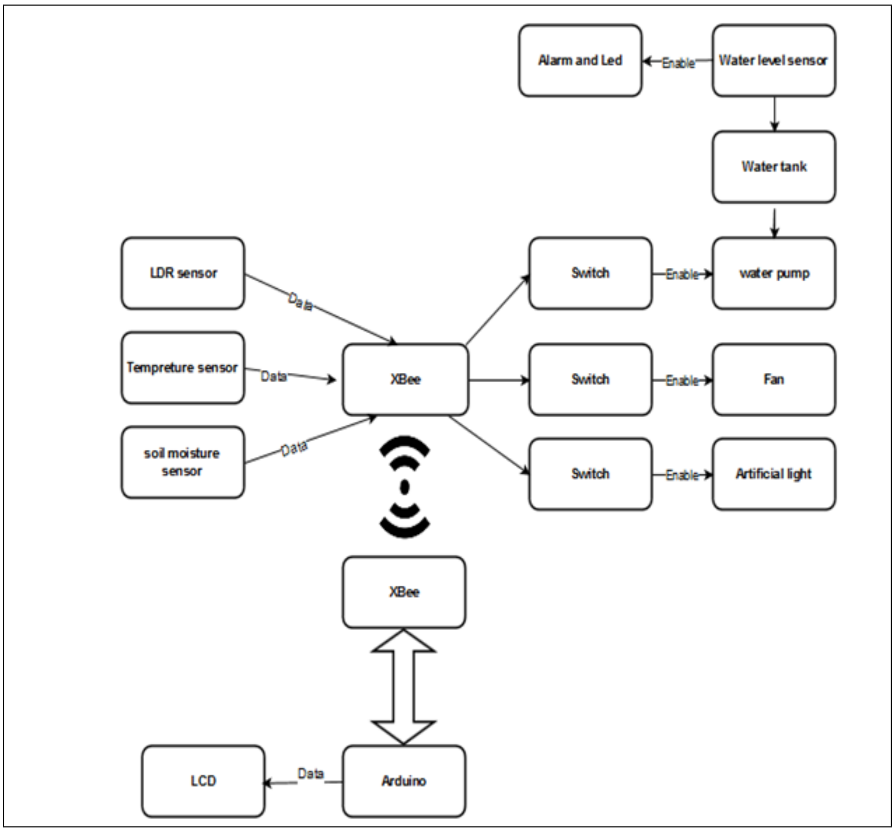

Figure 4.1: Block diagram.

Figure(4.2) shows the basic system abstraction diagram, and how components are connected together.

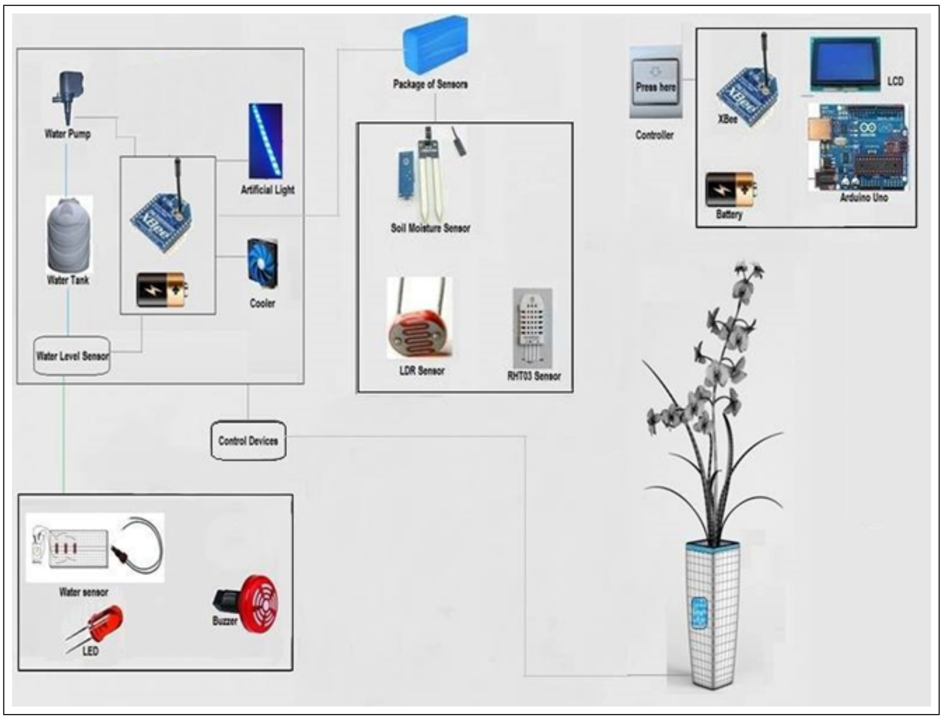

Figure 4.2: Basic system abstraction.

Figure(4.3) shows schematic diagram for the whole system.

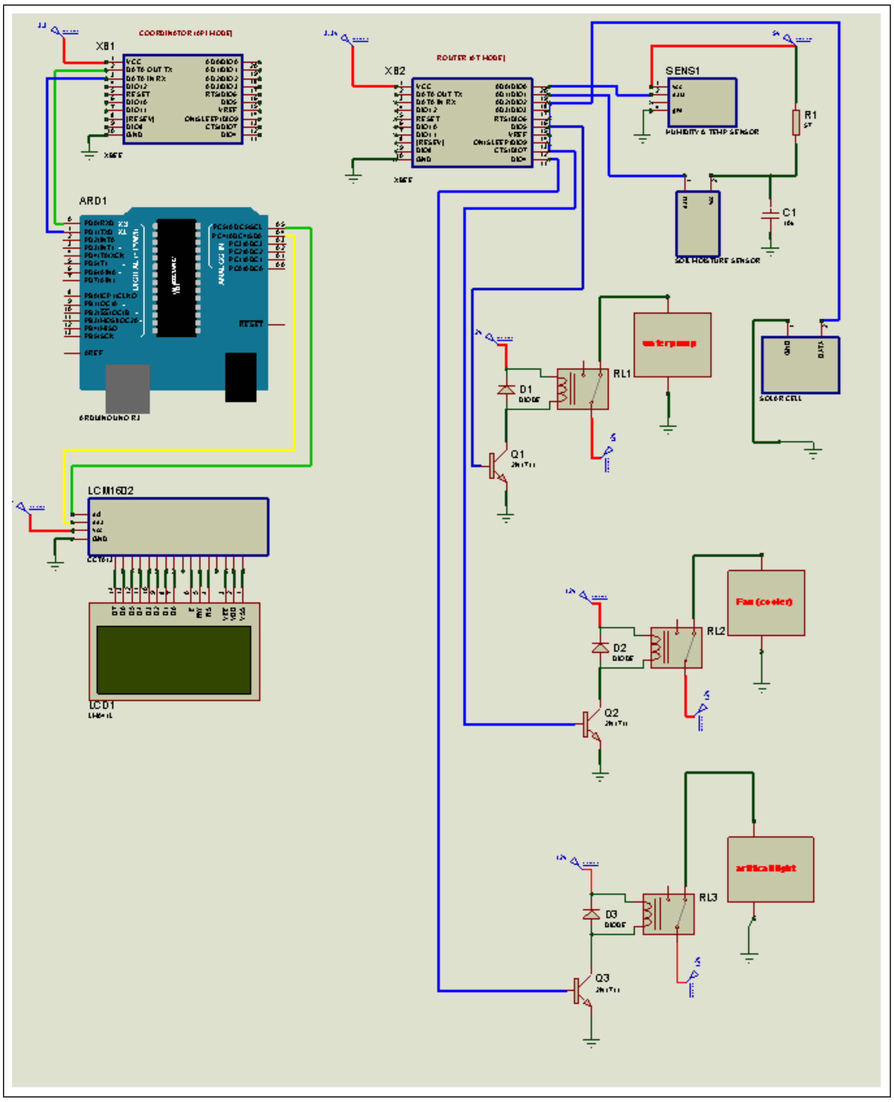

Figure 4.3: schematic diagram.

4.3 Design Options

Options are a wide world if we want to do anything we must consider all options in order to choose the most suited one. That's why we considered different options in designing our project, for example in choosing the microcontroller we considered the PIC or the Arduino kit and we choose the Arduino for several reasons that are explained in the next section, exactly the Arduino Uno because it has less numbers of input/output pins that's enough for our project.

Another option was to use the Wi-Fi technology or the XBee module technology to make wireless communication between microcontroller and other devices. We choose the XBee module for reasons will be explained in next section.

4.4 Analysis of Each Option

Why we choose the Arduino instead of PIC

The biggest difference is that a PIC is just a chip, while an Arduino is a platform. Yes the Arduino is expensive to have multiples, but it is rather plug and play, the PIC will require some external circuitry. If you are looking for something a little more apples to apples check out the chip that controls the Arduino. It is an Atmel part. The Arduino provides a layer of abstraction from most of the natty gritty aspects of the chip, while there are no any similar programs for the PIC.

The PIC can be programmed in assembly or C, the same as the Atmel AVR chips. Arduino has the high-quality C/C++ compiler, and the simplified IDE, and targets a different audience. The biggest advantage of the Arduino as a platform is that the system (the shields, the programming environment, and the documentation) allows for fast and simple setups with minimal debugging of the processor circuits, they work [8].

Why we choose the Arduino UNO instead of MEGA

We choose Uno instead of mega because we need a few number of I/O pins. Arduino mega has 70 I/O pins but uno has 20 I/O pins that are enough for our project. Also software on mega is non-standard, but on uno there is more code, more help online, and more details on how to work it. Table 4.1 shows some of differences and similarities between Arduino UNO and MEGA [9].

Why we choose XBee module instead of Wi-Fi

Although XBee has Low data rate (250kbit/s), it has low power consumption .But Wi-Fi has high power consumption. The XBee module also is bi-directional that means it transmits and receives in both directions, so you can easily test (at both ends) if the system is working correctly, but Wi-Fi only transmit in one direction. Each XBee unit has a unique serial number. This means two (or more) units can be set up to exclusively talk to each other, ignoring all signals from other modules. This is not easily achieved with other systems [10].

Chapter 5

Software

5.1 Chapter overview

In this chapter we will define the software component used to control our system in addition to explain how we configured our XBee modules to satisfy specific requirements.

5.2 Software components

Several main programs used in our project:

5.2.1 Arduino software (ARDUINO 1.6.3)

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. You can tell your Arduino what to do by writing code in the Arduino programming language (in our project we use C language), then make sure there is compile with no errors and upload the program to Arduino board.

5.2.2 Proteus And Fritzing

Proteus software used to draw the schematic diagrams, and fritzing used to draw 3D detailed diagrams.

5.2.3 X-CTU

Software used for configuring and testing Digi RF (Radio frequency) products modems.

5.3 XBee Configuration Using X-CTU

In our project we have two XBee modules one as a router and the other one as a coordinator. X-CTU used to configure them as following:

5.3.1 Coordinator

We used Modem Configuration tab to read, modify, and write changes to the XBees. It also used to update the firmware on the module. Configuration steps have been done as following:

1. Read tab used to display the configuration settings.
2. Firmware was updated to (Function Set: ZIGBEE COORDINTOR API).
3. Pressed on 'Write tab' To write the parameter changes to the radios non volatile memory.
4. Identified pan id (personal area network ID). Each network is defined with a unique PAN identifier (PAN ID). This identifier is common among all devices of the same network.

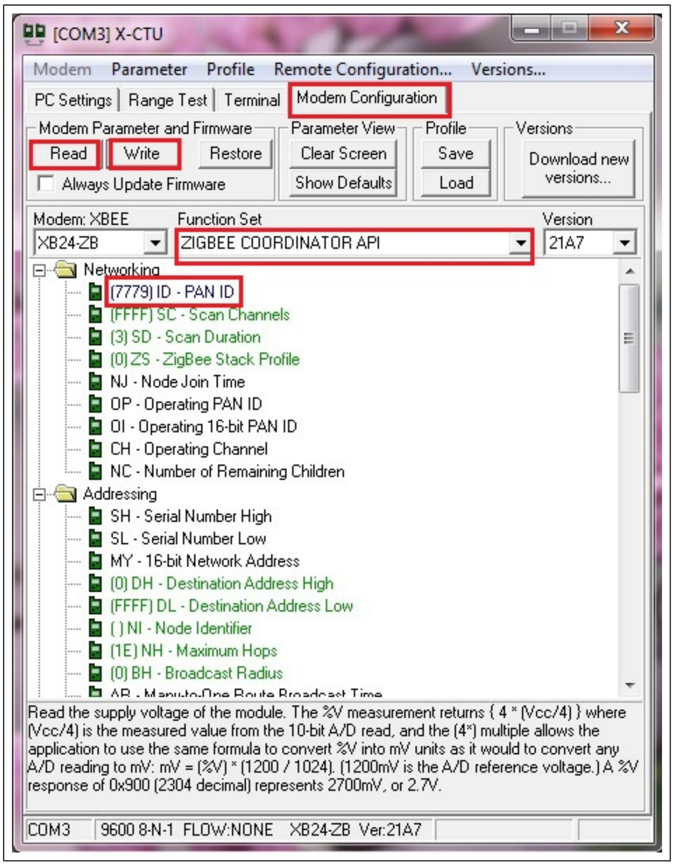

Figure 5.1: Coordinator setting.

5.3.2 Router

1. As in coordinator, firmware was updated to (Function Set: ZIGBEE ROUTER AT)

2. We pressed on 'Write tab' To write the parameter changes to the radio's non volatile memory.

3. Identified pan id (used the same number that used in coordinator).

4. Set channel verification as enabled, thats mean a router will verify a coordinator exists on the same channel after joining or power cycling to ensure it is operating on a valid channel .

5. Changed the functionality of each individual I/O pin on the XBee module.

6. I/O sampling rate was identified.

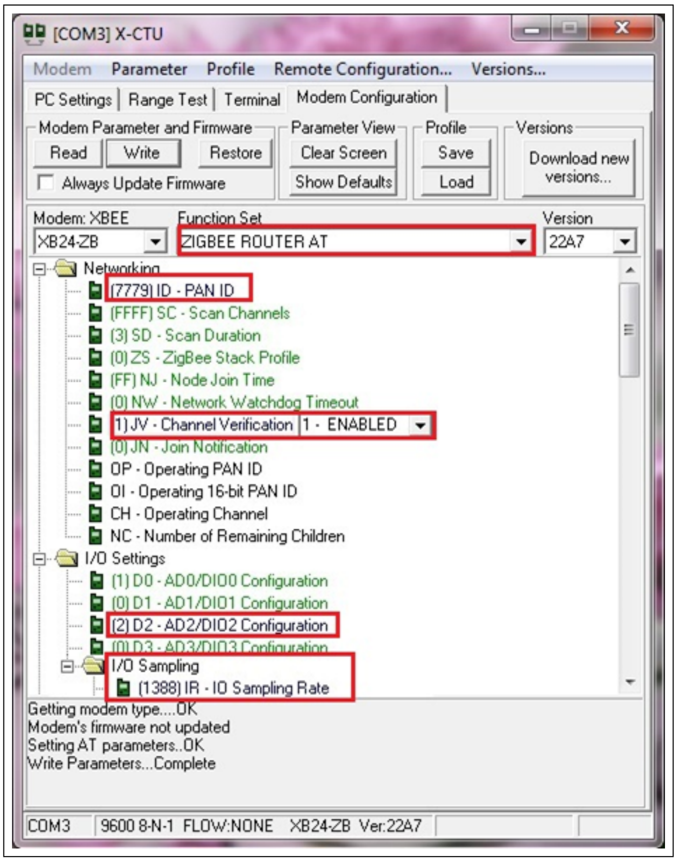

Figure 5.2: Router setting .

5.4 Flowchart

We built the software that controls our system as shown in the following flowchart (Fig 5.3).

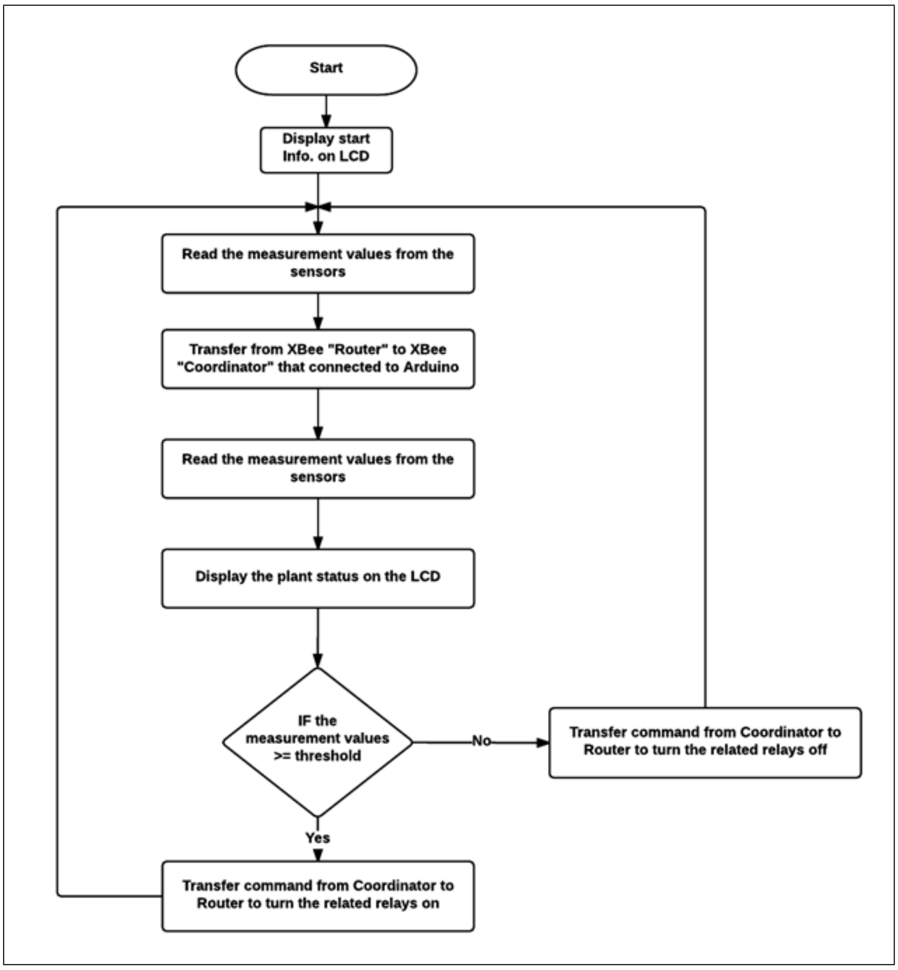

Figure 5.3: system flowchart .

Chapter 6

Validation and Discussion

6.1 Chapter Overview

In this chapter we will show and explain the implementation of the system which we did step by step, implementation challenges that we faced and the implementation of integrated system. In addition we will present the test of each subsystem and the results of hardware design and software sub codes.

6.2 Subsystems Implementation

Our system divided into number of subsystems.

6.2.1 Coordinator XBee Implementation

This subsystem is the heart of our system and common for all other subsystems. Coordinator XBee is connected with Arduino uno microcontroller, in order to enable transmitting to and receiving from rest of the system.

As shown in Figure 6.1 , VCC and GND pins in XBee are connected with 3.3V and GND pins in Arduino Respectively. Also TX (Data out) in XBee is connected with RX in Arduino and RX (Data in) connected with TX.

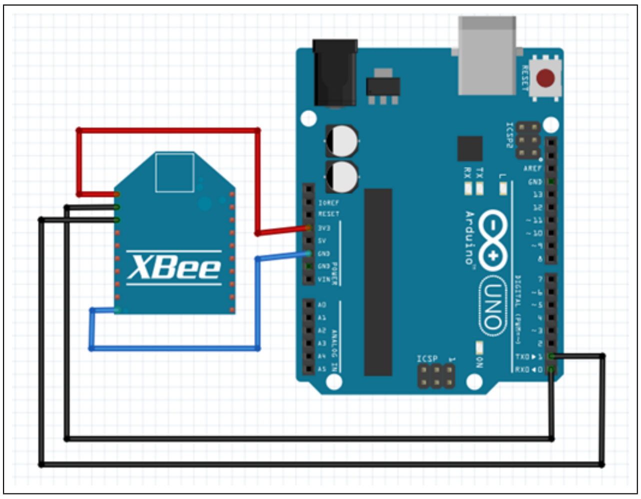

Figure 6.1: Coordinator XBee implementation.

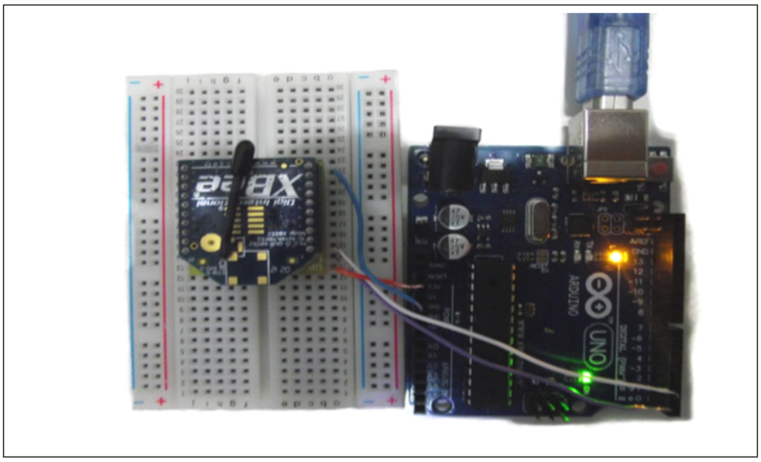

Figure 6.2: Coordinator XBee with Arduino.

6.2.2 Router XBee with Soil Moisture Sensor and Water Pump Implementation

Soil moisture sensor and water pump are connected with Router XBee. As shown in figure 6.3, Soil moisture sensor connected with pin (AD2) in XBee, and water pump connected with relay module that driven by 12V battery, the other side of relay is connected with pin (AD3) in XBee.

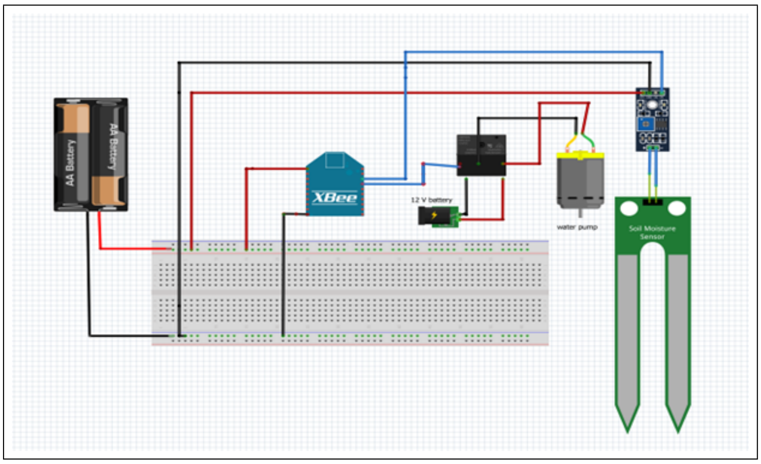

Figure 6.3: Router XBee with soil moisture sensor and water pump implementation.

Code in figure 6.4 used to implement the sub system shows in figure 6.5 :

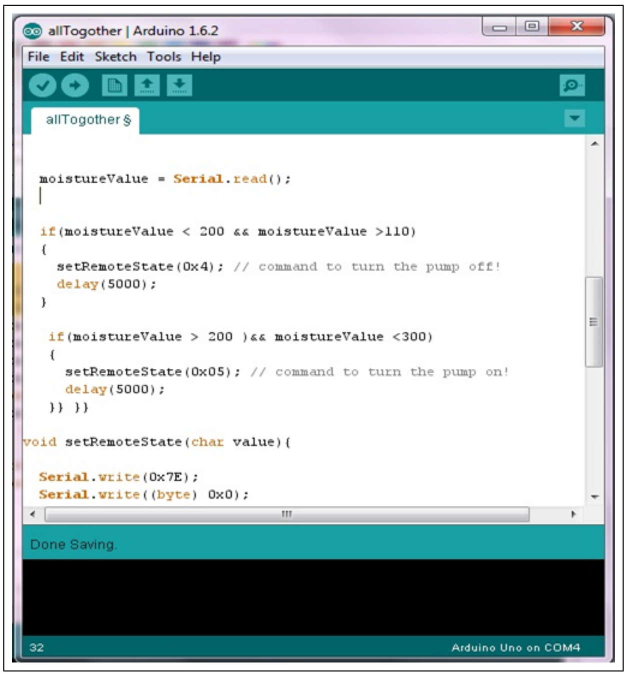

Figure 6.4: soil moisture sensor code.

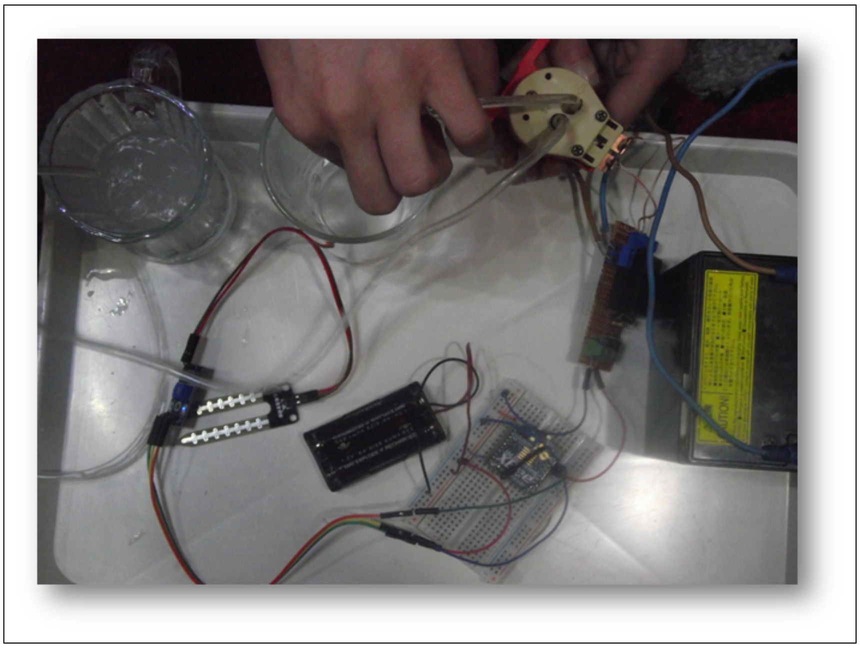

Figure 6.5: soil moisture sensor and water pump testing .

When we put soil moisture sensor in a dry soil, the value of soil moisture transmitted from router XBee to coordinator XBee which is connected with microcontroller. The microcontroller issued a command to router XBee in order to turn on the relay connected with water pump to provide soil with the perfect amount of water.
The system gives a warning to the user when the water ends from the tank, by placing a water level sensor and connects it with alarm and led they work when the water reaches to the lowest level as shown in figure 6.6 .

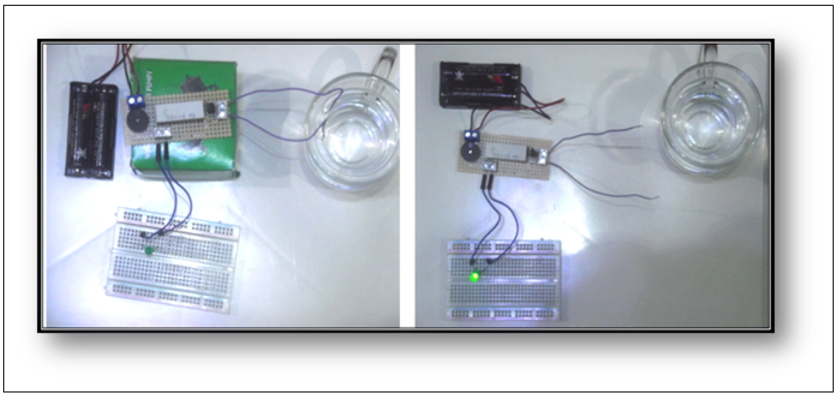

Figure 6.6: water level sensor .

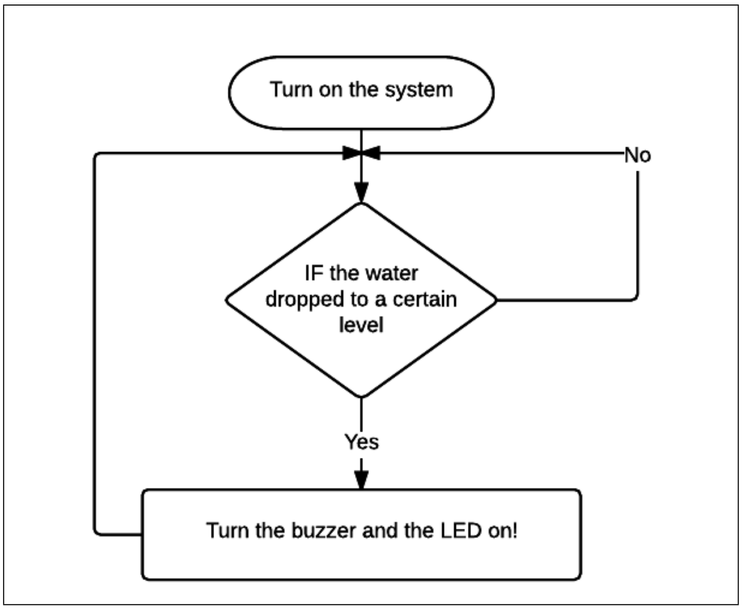

Figure 6.7: water level sensor flowchart.

6.2.3 Router XBee With Temperature sensor and Fan Implementation

Figure 6.8 presents the connection of temperature sensor and fan with router XBee; its the same as soil moisture sensor and pump in figure 6.3.

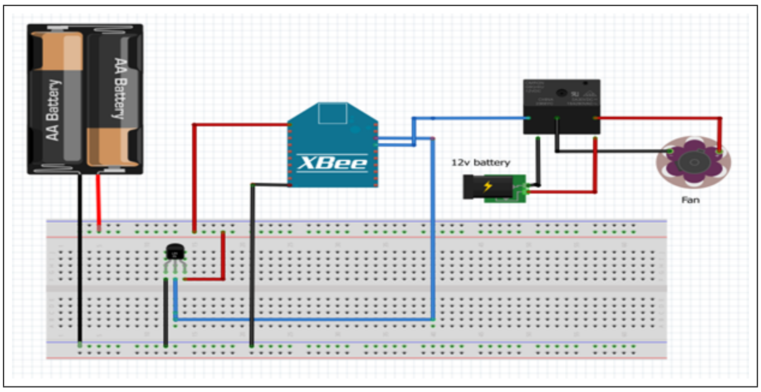

Figure 6.8: Router XBee with Temperature sensor and Fan implementation.

Code in figure 6.9 used to implement the sub system shows in figure 6.10

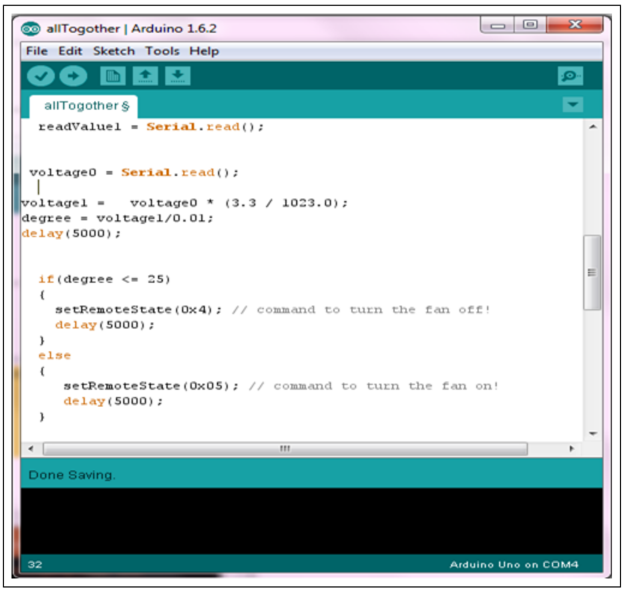

Figure 6.9: temperature sensor codes.

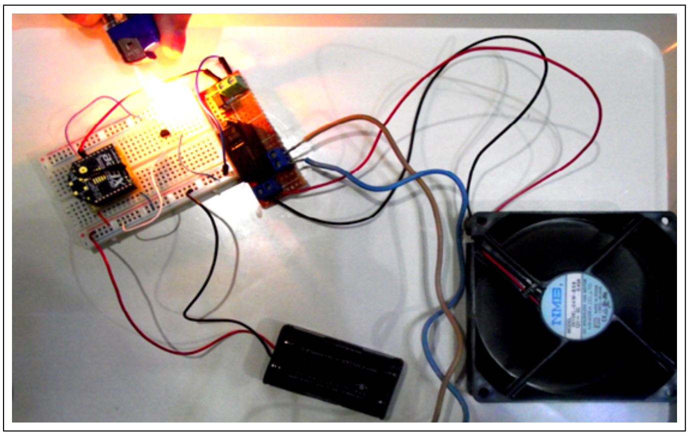

Figure 6.10: Router XBee with Temperature sensor and Fan testing.

Temperature sensor sensed the increase of temperature and sent the value from router XBee to coordinator one that is connected with Arduino which compares received value with threshold and issued a command for router XBee to turn on the relay that is connected with Fan.

6.2.4 Router XBee With LDR and Artificial Light Implementation

Figure 6.11 displays the connection of LDR and artificial light with router XBee, is the same as previous connection presented in Fig 6.8 and Fig 6.3.

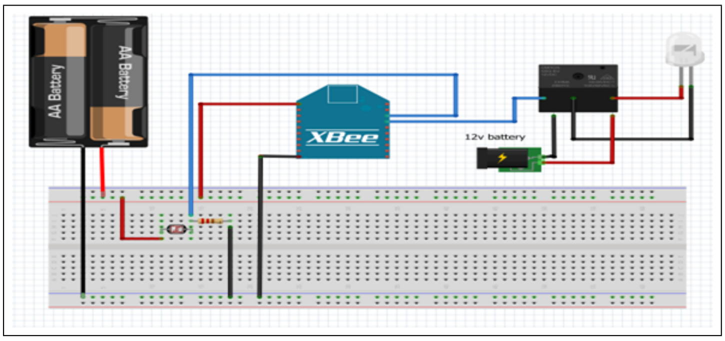

Figure 6.11: Router XBee with LDR and artificial light implementation.

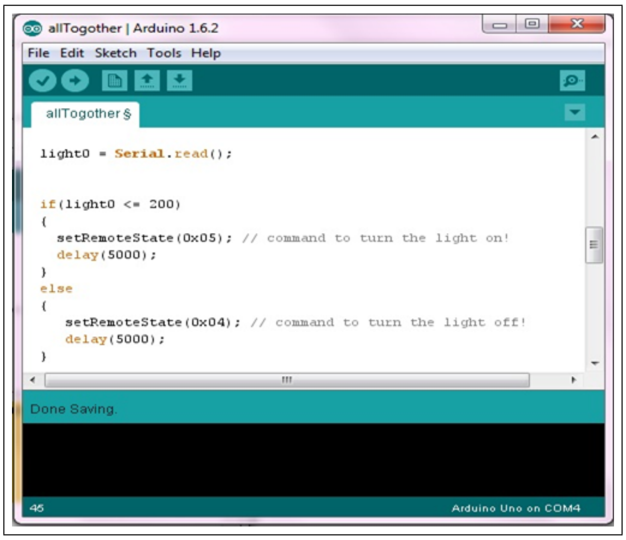

Figure 6.12: LDR code .

We used the above code to test subsystem in figure 6.13
LDR sensor sensed the decrease of light density and sent the value from router XBee to coordinator one that is connected with Arduino which compares received value with threshold and issued a command for router XBee to turn on the relay that is connected with artificial light .

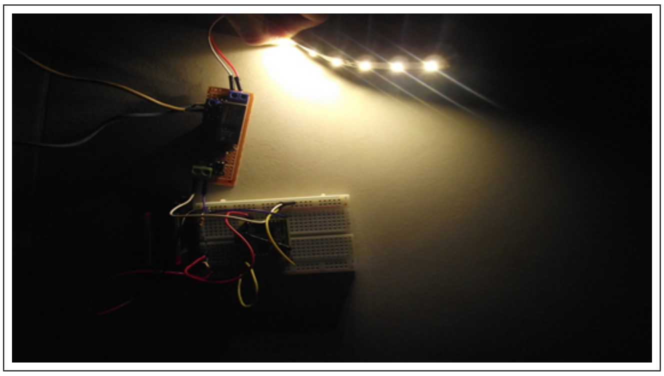

Figure 6.13: Router XBee with LDR sensor and artificial light testing.

6.2.5 LCD Implementation

The LCD is used for interfacing with user; it shows the status of climate parameters (temperature, soil muster). Figure 6.14 shows the connection of the LCD with Arduino serially.

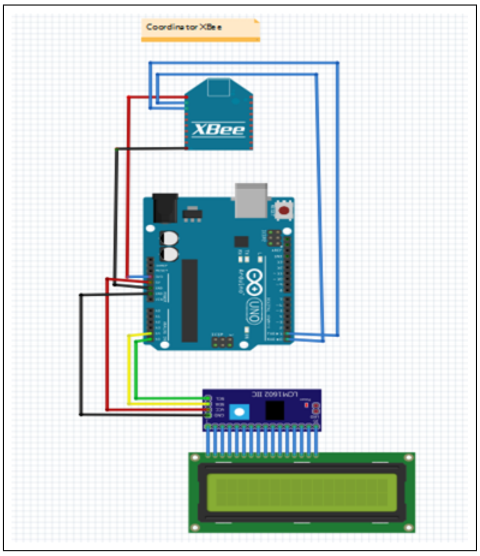

Figure 6.14: LCD implementation .

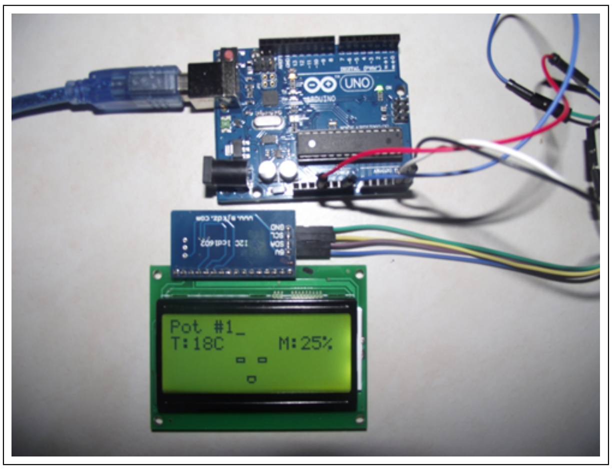

Figure 6.15: LCD testing .

6.3 Implementation Challenges

In this section we will explain the challenges that we faced during the implementation and designing of the system, and how we tried to solve them.

XBee New Version This is the first challenge that we faced, the XBee we used is a new version, there was a lot of difficulties in using it since it's a new version there were no enough references for us to use them. It was very difficult to know how to start to implement it.

LDR and Timer The second challenge was the LDR, the needed action is that LDR measures the percentage of light in the pot and depending on that the Arduino gives the order whether to turn on the artificial light or not, the main problem was the night. As we all know there is no light in the night so the LDR will measure the variable and the Arduino will compare it with the threshold and it will found it less than the threshold so it will send the command of turning on the artificial light, but this is not sufficient, so we solved it by using a timer in order to turn on the light for a specific time only.

LCD With XBee As it was to be the LCD was decided to be connected with the router XBee, but in order to do that we must use the SDK which is not available and it's very difficult and time consuming to provide it, so we decided to connect it with the Arduino as an alternative solution.

6.4 Integrated System Implementation

The final stage is to connect all the previous subsystems together to get the final circuit. The whole system implemented as shown in the Figure 6.16, the system also has been tested as a whole, and all the required actions and cases worked successfully.

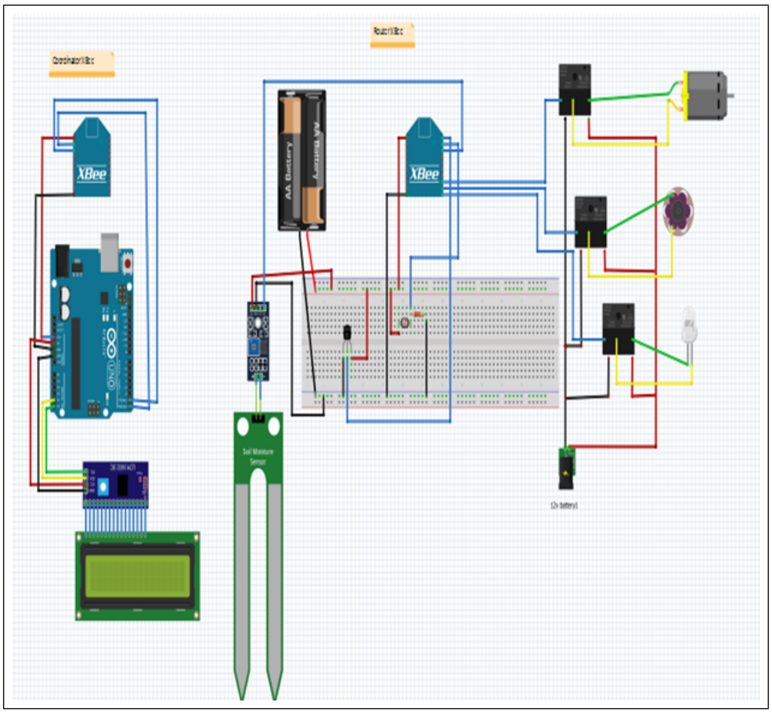

Figure 6.16: Integrated system.

Chapter 7

Conclusion

7.1 Chapter Overview

In this chapter we will consider all conclusions of the project, in addition to future works that can be developed on the system.

7.2 Conclusion:

After working on this system, we will describe it in this section in a few words in order to be a stand-alone description. This system had been developed and implemented to control the climate variables for houseplants, in order to protect them and to provide perfect environmental variables. The system is mainly divided into two parts, the first part is located inside the pot, it includes all of the sensors that will measure the change on climate variables, it also includes the controlling devices such as water pump, fan and artificial light, in addition a router XBee that sends the signals to the second part of our system. Now, the second part of the system is the main controlling part, in this part, the coordinating XBee is connected with the Arduino, the XBee receives the signals from XBee in first part and compares it with the data stored in the Arduino previously. Then depends on the comparison result a specific command will be sent to coordinator, and from coordinator to router in order to perform required action.

7.3 Future Works:

In this section, the future work will be explained in order to be the guide for any development.

1. Our project is implemented for a single pot only; it can be expanded to many pots for the same system.
2. The system can be expanded and developed for other usages such as greenhouses.
3. For a future developing, we can connect our system with a database provided on the internet so that any update on the internet database will be updated to our system synchronously.

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