

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Palestine Polytechnic University
College of Engineering



Smart Farming Using IoT Technologies

Project Team

Asem Abu Omar

Layth Saafin

Tamer Al-Rajabi

Project Supervisor

Eng. Jalal Al-Salayma

Eng. Ayman Wazwaz

Submitted to the College of Engineering by the corporation
between the Mechanical Department and Electrical Department
in partial fulfillment of the Bachelor's Degree.

Hebron, 2020

Abstract

Agriculture and farmers face a set of problems and among the most important of these problems, directly affect the growth and productivity of the plant represent the problem of the farmer's inability to accurately control the quantities of water suitable for each plant, and the quantities of fertilizers used, and their quality that provides nutrition for a plant of chemical compounds, and elements that the soil essentially depends on plant growth. As well as the problem of continuous monitoring of plants and the changes that are taking place on them continuously from environmental factors like the amounts of rain, the intensity of the wind, the intensity of heat and frost, that directly affects the growth and persistence of the plant to obtain the best possible crop from them.

Therefore, the project aims to propose a solution for this problem by computerizing greenhouses implementing the internet of things technologies on electrical gadgets, that used for farming process form sensors and devices, that can remotely monitor using smart devices (Computers and smartphones) through wireless Internet networking technologies, to control some of the affecting factors the agricultural process, to reduce the amount of the consumed water, and make the atmosphere suitable for growing plants with higher quality and greater quantities, so that the Palestinian product would be able to compete in the internal and regional markets.

A prototype of the mini-agricultural system has been designed, with the parameters that affect the agricultural process. And achieved the process of monitoring more than ten sensors and prob and controlling about twelve devices. And scheduled the appropriate dates for the agricultural process, and put the programming conditions on the readings of the sensors to work on controlling the devices that in turn fix the agricultural factors.

الملخص

تواجه الزراعة والمزارعين مجموعة من المشاكل، ومن اهم هذه المشاكل التي تؤثر بشكل مباشر على نمو النبتة ونتاجيتها مشكلة عدم قدرة المزارع على التحكم الدقيق بكميات المياه مناسبة لكل نبتة وكميات الاسمدة المستخدمة ونوعيتها التي توفر التغذية لنبات من مركبات الكيميائية وعناصر التي تحتاجها التربة بشكل اساسي ويتوقف عليها نمو النبات وأيضا مشكلة المراقبة المستمرة لنباتات وتغيرات التي تجري عليهم بشكل مستمر من عوامل بيئية مثل كميات الامطار وشدة الرياح وشدة الحرارة والصقيع وغيرها، التي تؤثر بشكل مباشر على نمو واستمرار النبتة والحصول على افضل محصول ممكن منها.

لذلك نقترح في هذا المشروع حلاً لهذه المشاكل عن طريق حوسبة الدفيئات، بتطبيق تقنيات الإنترنت الأشياء على الأدوات الكهربائية وأجهزة الإستشعار التي تستخدم في عملية الزراعة، ومراقبتها عن بعد، باستخدام الأجهزة الذكية (أجهزة الكمبيوتر والهواتف الذكية) من خلال تقنيات شبكات الإنترنت اللاسلكية للسيطرة والتحكم على العوامل المؤثرة في العملية الزراعية. بهذا يعمل على تقليل كمية المياه المستهلكة، وجعل الجو مناسباً لنمو النباتات بجودة أعلى وكميات أكبر.

لقد صُمم نموذجاً أولياً لنظام الزراعة المصغرة، مع الأخذ بعين الإعتبار المعايير التي تؤثر على العملية الزراعية. وتم التحقق بعملية مراقبة لأكثر من عشرة مجسات وحساسات، وتم تنفيذ عملية التحكم لنحو إثني عشر جهازاً. وجدولت وحددت المواعيد المناسبة للعملية الزراعية، ووضعت شروط البرمجة على قراءات المجسات لتعمل على ضبط الأجهزة التي بدورها تصلح العوامل الزراعية.

Acknowledgment

All the thanks and respect to our Palestine Polytechnic University.

Thanks, and appreciation to our Engineering College.

Special thanks and gratitude to our departments the Electrical and Mechanical Departments, for helping us assembling this Project.

Thank you to our supervisors, Eng. Jalal Al-Salayma and Eng. Ayman Wazwaz, for providing guidance and feedback and overall insights throughout this project. thanks to Eng. Alaa Al-Tamimi and Eng. Fouad Al-Zaro for cooperating with us in the work of the PCB.

To

I dedicate this work to our dear parents, our family, and our dears.

To our green land, for an olive tree that has uprooted.

To the farmer that his land has been usurped.

To the toilers and farmers of our beloved land.

الإهداء

أُهدي هذا العمل لوالدينا الكرام ولأهلي وأحبتي
لوطني الأخضر، ولشجرة الزيتون التي أقتلعت غصبا،
ولذلك الفلاح الذي أغصبت أرضه،
إلى الكادحين والمزارعين في أرضنا الحبيبة.

Contents

1	Chapter One Introduction.....	1
1.1	Overview	2
1.2	Background	2
1.3	Problem Statement	2
1.4	Importance.....	3
1.5	Motivation	3
1.6	Terminology	4
1.7	Strategy and Related work:	4
1.8	Methodology	5
1.9	Components of the Project System	5
1.10	Project outline	7
1.11	Timeline:	7
1.12	Project Budget	8
1.13	Literature review	9
2	Chapter Two Conceptual Design and Functional Specification	12
2.1	Overview	13
2.2	Needs and Requirement	13
2.3	Shape and Dimension Selection.....	13
2.4	Irrigation Design	14
2.5	Proposed Designs	15
2.6	Block Diagram	16
2.7	Specification.....	21
3	Chapter Three Electrical Design	23
3.1	Overview	24
3.2	Fan.....	24
3.3	Water Pump.....	26
3.4	Water Solenoid Valve	26
3.5	Sensors	27
(1)	Ultrasonic Level Sensor	27
(2)	Flow Sensor switch	27
(3)	pH level in the soil sensor	28

(4)	Light Sensor	29
(5)	Soil moisture Sensor.....	29
(6)	Rain Drop Sensor	30
(7)	Humidity & Temperature Sensor	30
3.6	Controllers and IoT Devices	31
3.7	Relays.....	31
3.8	Analog Digital Sensor Module.....	32
3.9	Electrical protection and isolation circuits	33
3.10	Electrical Power Source	33
4	Chapter Four Software Design.....	34
4.1	Introduction	35
4.2	System Layout.....	35
4.3	System Main Parts.....	36
(1)	ESP 8266 Wi-Fi Microcontroller	36
(2)	ESP WROOT 32 Wi-Fi Microcontroller	37
(3)	ESP01 WITH 4 Relay - ESP 8266 E01 4 channel Wi-Fi Microcontroller	39
(4)	Database	40
(5)	Internet Access	40
(6)	Sensors and measurement devices	41
(7)	Electrical Motor and liquid valves devices	41
(8)	Platform and System Application	41
4.4	Connectivity principles	44
4.5	The ALGORITHM SYSTEM.....	47
5	Chapter Five Results	48
5.1	Hardware results.....	49
5.2	Software results	53
(1)	Application Results	53
(2)	Web Browser Results	56
(3)	Scheduling Results	58
(4)	Triggers and Alerts Results	60
5.3	How to use the Project	62
5.4	Prototype Results.....	68
	Recommendations	69
	Appendix	70

A Green House Solar System.....	70
B The Alternative System	73
(1) The System Layout.....	73
(2) System The main Parts	74
(3) The Panasonic Programmable Controller FP7	74
(4) The Panasonic Multi I/O	76
(5) The Panasonic Analog input/output	76
(6) The Panasonic Application main system	76
(7) Database as a local computer	79
(8) Internet Router.....	79
(9) Sensors and measurement devices	79
(10) Electrical Motor and liquid valves devices.	79
(11) Connectivity principles	80
(12) The Algorithm system.....	81
(13) The cost of the system.....	82
References	83

List of Figures

Figure 1.1 Methodology chart.....	5
Figure 1.2 The components with description	6
Figure 2.1 Block of IoT controller 6 with connected gadgets.....	19
Figure 2.2 Block of IoT controller 7 with connected gadgets.....	19
Figure 2.3 One Big Block Diagram that contains all Gadgets together	20
Figure 3.1 The Fan used.....	24
Figure 3.2 Water Pump [11].....	26
Figure 3.3 Water Solenoid Valve [12]	26
Figure 3.4 Ultrasonic Level sensor and the location site in the tank [13].....	27
Figure 3.5 Flow Sensor Switch [14].....	28
Figure 3.6 pH level in the soil sensor [15]	28
Figure 3.7 Light Sensor [16]	29
Figure 3.8 Soil moisture Sensor [17]	29
Figure 3.9 Rain Drop Sensor with Analog Digital Module [18].....	30
Figure 3.10 DHT 11- Humidity & Temperature Sensor [19]	30
Figure 3.11 IoT Controller ESP 01 [20].....	31
Figure 3.12 IoT Controller ESP 32 [20].....	31
Figure 3.13 IoT Controller ESP 8266 D1 MINI [20].....	31
Figure 3.14 Relays with Optocoupler circuit [21].....	32
Figure 3.15 Relays [21].....	32
Figure 3.16 Contactor [18].....	32
Figure 3.17 Opto-coupler Circuit [22]	33
Figure 3.18 Ni-MH batteries [23]	33
Figure 4.1 System layout Scheme	35
Figure 4.2 Definition and Layout Nude MCU – ESP 8266	37
Figure 4.3 Pin Definition and Layout ESP WROOT 32	38
Figure 4.4 ESP01 WITH 4 Relay with Pin Definition and Layout.....	40
Figure 4.5 Cayenne Works Layout	44
Figure 4.6 ESP WITH 4 Relay Work layout.....	45
Figure 4.7 ESP WROOT 32 Work layout.....	46

Figure 4.8 ALGORATHIM SYSTEM.....	47
Figure 5.1 - 1 st Controller, Ultrasonic Level Sensor, and Water flow sensor.	49
Figure 5.2 - 2 nd Controller, Rain sensor, Light sensor, and DHT 22	49
Figure 5.3 - 3 rd Controller, and 4 Relays	50
Figure 5.4 - 4 th Controller, DHT 11, and Soil Moisture Sensor.	50
Figure 5.5 - 5 th Controller, and 4 Relays	51
Figure 5.6 - 6 th Controller, DHT 11, Soil Moisture Sensor, and ADC Modules for Soil pH, Soil Moisture, Lights.	51
Figure 5.7 - 7 th Extension Controller and 4 Relays	52
Figure 5.8 Cayenne Icon	53
Figure 5.9 Project Window	54
Figure 5.10 Monitor the probes Window	54
Figure 5.11 Relay Window	55
Figure 5.12 Up Times Window	55
Figure 5.13 Browser three taps.	56
Figure 5.14 Monitor the probes Window tap.	56
Figure 5.15 Uptime Window tap.....	56
Figure 5.16 Relay Window tap.	57
Figure 5.17 The Menu Bar	57
Figure 5.18 the scheduling button	58
Figure 5.19 Events List	58
Figure 5.20 the Start Watering Edit Event Window.	59
Figure 5.21 daily schedule system in monthly view	59
Figure 5.22 The Trigger and Alerts button	60
Figure 5.23 A Triggers List.....	60
Figure 5.24 A Triggers List Cont.	60
Figure 5.25 list of Triggers in Android Application.	61
Figure 5.26 the sign-up page	62
Figure 5.27 choose Device panel	62
Figure 5.28 Manage Libraries Panel	63
Figure 5.29 The Library Manager dialog	63
Figure 5.30 Board menu.....	64
Figure 5.31 Port menu.....	64
Figure 5.32 the list of supported boards	65

Figure 5.33 MQTT credentials in the global void.....	66
Figure 5.34 Main Menu.....	66
3. Click the Step 1: Sketch File button to view the sketch file. Figure 5.36	66
Figure 5.35 Add New Device Panel.....	66
Figure 5.37 Arduino IDE After pasting a code.	67
Figure 5.38 Sensor button that recently added.	67
Figure 5.39 Prototype Top View	68
Figure 5.40 Prototype Back View	68
Figure 5.41 Prototype Front View.....	68
Figure 0.1 Connection of the components	71
Figure 0.2 Connect the solar system to the green house	71
Figure 0.3 space between solar cells	72
Figure 0.4 component placed in one panel.....	72
Figure 0.5 The System Layout.	73
Figure 0.6 Ethernet Connectivity [25].....	75
Figure 0.7 Panasonic Application main system [25].....	77
Figure 0.8 WEB Server function [25]	77
Figure 0.9 E-mail sending [25]	78
Figure 0.10 Local & remote connectivity [25].....	78
Figure 0.11 HTTP(S) client function [25].....	80
Figure 0.12 FTP(S) client function [25].....	80
Figure 0.13 Algorithm system.....	81

List of Tables

Table 1.1 Timeline	7
Table 1.2 Project Budget	8
Table 2.1 Specifications	21
Table 0.1 The Cost of the alternative system	82

1 Chapter One Introduction

- 1.1 Overview
- 1.2 Background
- 1.3 Problem Statement
- 1.4 Importance
- 1.5 Motivation
- 1.6 Terminology
- 1.7 Strategy and Related work
- 1.8 Methodology
- 1.9 Components of the Project System
- 1.10 Project Outline
- 1.11 Timeline
- 1.12 Project Budget
- 1.13 Literature review

1.1 Overview

This chapter presents a general description of the system, starting with background, objectives, the importance of the system, requirements, motivation, project schedule, and time planned budget.

1.2 Background

The project is an intelligent system that self-control the agricultural process, build in IoT systems with a synchronized database, microcontrollers, and mechanical techniques that can make actions by monitoring and study some of agricultural parameters.

1.3 Problem Statement

The Palestinian agricultural sector lies between the fangs of the Israeli occupation on the one hand, and the Palestinian consumer and their awareness on the other, Its main problems are the lack of plant nutrients, such as iron and nitrogen that are useful for growth, and the problem of soil salinization, as in Gaza, for the leakage of sea water and wastewater to the infrastructure, [1] And the problem of climate changes, fluctuations in rain and unstable monsoons, too, which in turn leads to other problems in the soil, such as desertification.

The scarcity of water resources, as the Israeli occupation controls most of them, and imposes restrictions on farmers on the amount and methods of water consumption, restricting them to the depth of water wells, they didn't allow digging them, and deny them the supply of irrigation systems from water springs or underground wells of Palestine, Apart from the wastewater tunnels they throw into the water fountains that flow to the Palestinians.

As for imported goods, they compete in the Palestinian market despite the vast agricultural areas. [2]

1.4 Importance

The agricultural sector is considered one of the most important sectors in any country, no matter how much the population increases or less, and whatever the size of the country is small or large, and the progress and prosperity of this country is dependent on the agricultural sector, as it is the basis for the rest of the sectors of industry and trade, all developed countries are keen to this sector, and attaches great importance to it because of the most important causes of progress, prosperity, prosperity, and self-sufficiency that this sector guarantees. [3]

And attention to the agricultural sector is not a modern one, but it is from ancient times, as the craft of agriculture is considered one of the first trades that people have practiced. It is the fundamental point that transformed a person from relying on hunting to switching to cultivation, which pushed the human to stability instead of permanent mobility, and the person became interested in building a house near his crops to take care of it, which was the main element for the establishment of civilizations instead of continuous mobility and housing in caves, and many of the received Judgment and sayings about the importance of agriculture, including: (There is no good in a nation that eats what is not sown and dressed in what it does not make). [4]

The project aims to help the farmers and reduce many sources, and helps in water consumption for irrigation in a smart controlled way, such as the water shortage issue that faces every farmer in our country, and leading to better productivity and quality.

1.5 Motivation

We have come from the first and essential need to promote the agricultural sector, Which is the backbone of the Palestinian economy, And through this work, it will improve the products and make them products of high quality and competitive in the market and double the quantities of production and raise the level of income of Palestinian farmers.

1.6 Terminology

Utilization of Advanced Technology in Greenhouses in Palestine from the Perspective of Agronomists.

Agriculture in Palestine suffers from several problems related to the availability of water and efficient use of the available farmlands. Besides, due to the current political and economic situation in Palestine, the agricultural sector is unable to supply the needed products for the local market. Therefore, farmers need to rely on modern technology such as the implementation of the internet of things (IoT) in greenhouses to increase their efficiency and facilitate their control, which will help to improve the overall production of the farming sector and overcome the current problems. Results show in last that the use of technology in the Palestinian agricultural sector has a positive impact. It leads to an improvement in the quality and the quantities of the products. However, advanced technology is used on a very limited scope, mainly because of its cost. Also, local farmers are not trained to use and manage modern tools and prefer to use traditional methods. [5]

Poverty is often a result of circumstances beyond an individual farmer's control,

So, they may face a drop in their income linked to increasing input costs and/or personal circumstances relating to ill health, and many causes like the leakage of water sources, not enough keep up with technology, Lack of optimal utilization of resources, Natural disasters, Shortage of workers, fatal epidemics of crops. [4]

1.7 Strategy and Related work:

- First, build a mechanical system that can be controlled, and compatible with the work nature of the farm, considering all farmers move.
- Second, install all the sensuous and measurement tools, so each part of the system takes their sensor in the body of the project.
- Third, construct a database connected to IoT systems, by internet connections and data transfer servers to the controller part of the project.
- Forth, connect the mechanical part with controllers and sensors, and start testing the project partly by part.
- Fifth, apply the database parameters to the IoT device that connects to the controllers.

1.8 Methodology

The methodology of the work arranged as follows in Figure 1.1 described the stream in the order:

First: Gathering agricultural information of agricultural institutions.

Second: Study and analyze the information's in detail.

Third: Convert information to spreadsheets.

Fourth: Converting information to sheets and tables that can a computer understand.

Fifth: install and setup all the settings for these collected data.

Sixth: operating system and monitoring the outputs.

Seventh: Feeding back operation.

1.9 Components of the Project System

The components with description figure 1.2:

1. Sensors and Measured tools:

- Water Ultrasonic level sensor, sense the water in the tank.
- The humidity sensor, measures both Air humidity and air temperature.
- Temperature Sensor, senses the entire temperature of the greenhouse.
- Soil Moisture Sensor, sense the soil moisture.
- pH Sensor, senses the pH value in the soil between acidic or basic ranges.
- Light Sensor, sense the sunlight, or environment light.
- Rain Drop Sensor, sense when the sky is raining.

2. Electro-Mechanical Components:

- Pump Motor, to pump water and mixed fertilizers to the plant.
- Selector valve, Liquid Switch for flow controls.
- Shutter motors, for the air window Shelter.

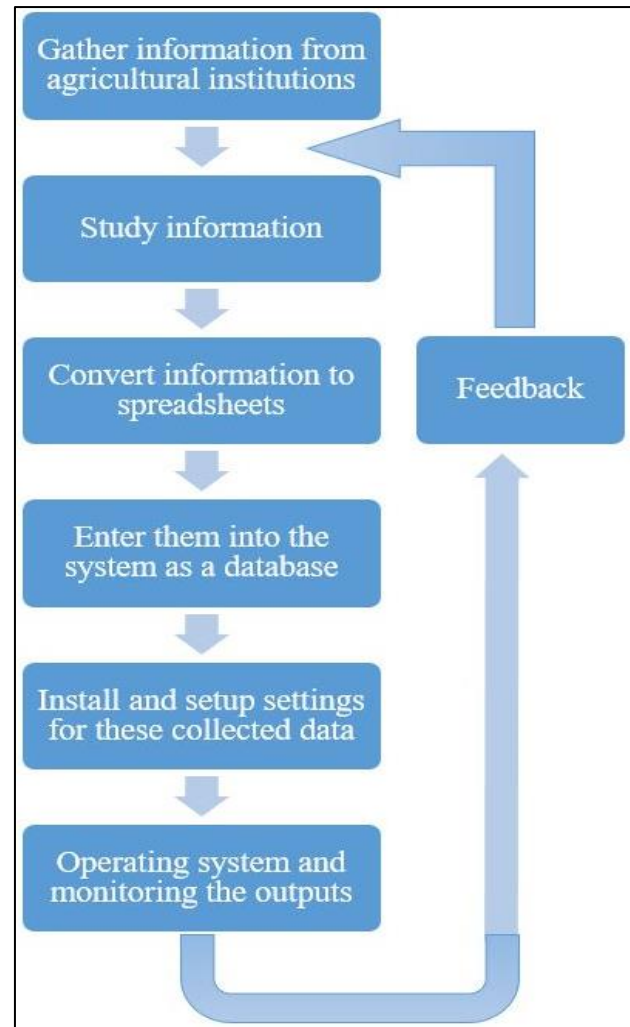


Figure 1.1 Methodology chart

- Fan motor, used to create flow within a greenhouse.

3. Electrical Components:

- Controllers, the main part of controlling and processing.
- Relays, to manage electrical Switching.
- Contactors, to manage Pump Motors.
- IoT Devices, to obtain the right parameters from the database.
- Electrical protection and isolation circuits, to protect low voltage circuits from the high voltage.

4. Interfacing Components.

PC, laptops, smartphones, browsing internet devices, to check, Monitoring, and give orders to the Control unit.

5. Internet Connectivity Components.

Internet Router, Server as Database or Computer as Database, to store collected data and holds the platform of the system.

6. Farming Components.

Pipelines, Water spray devices, advanced agricultural technology devices.

From the chart diagram in Figure 1.2 can describe the components of the project system.

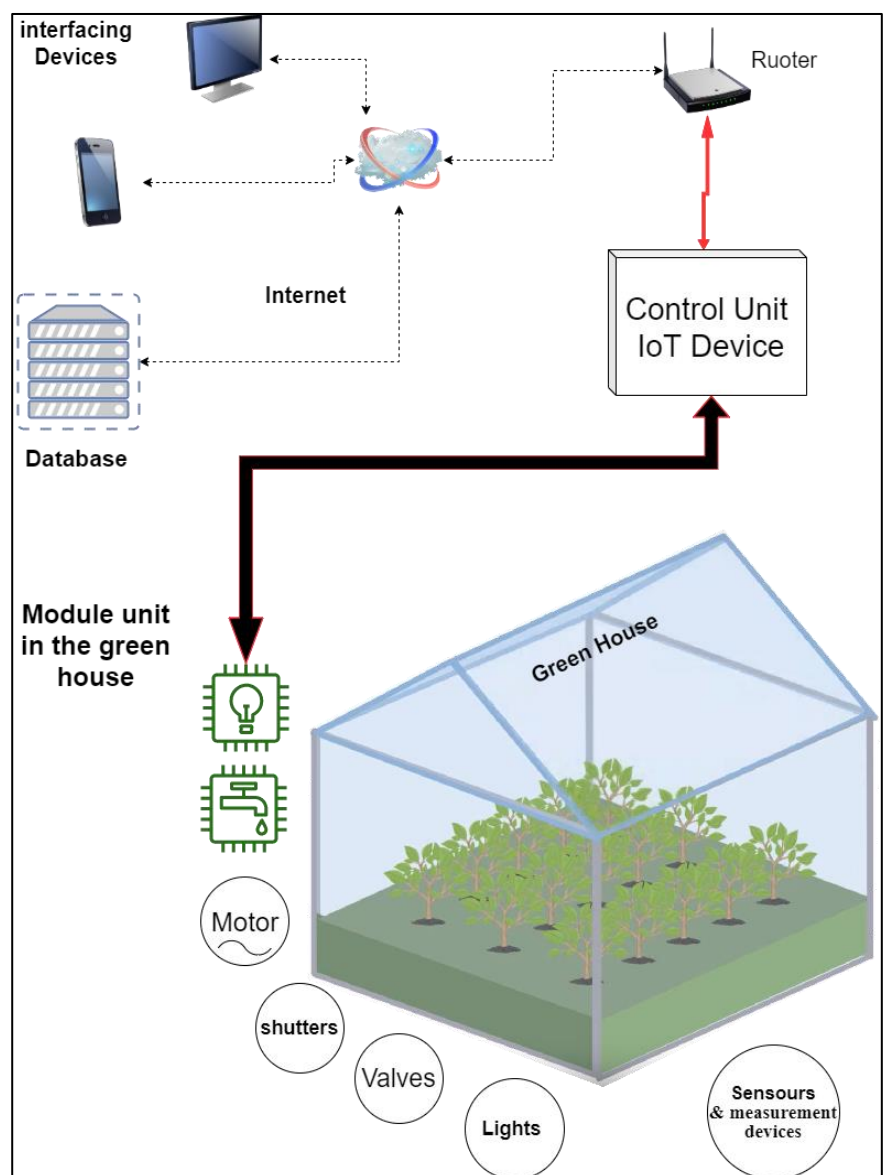


Figure 1.2 The components with description

1.10 Project outline

Project Scope to initiate a system that can be directing and monitoring and control the farming process

In chapter Two “ Conceptual Design and Functional Specification ” will dissipate the system to subsystems and will present the suggested design for every subsystem and describe the conceptual design of the project taking in the consideration the requirements and objectives that have been Clearfield in the previous chapter, and it describes the functional specification of the component and the integration between them.

In chapter Three “Electrical design” will discuss electric components used in the project, by considering a Criteria, Definitions, location.

In chapter four “Software design” explains the structure of the electronic and software system and what is happening inside the system from the internal components and what is being simulated with it.

In chapter five “Results” shown the operating results in the projects.

In chapter Six “Recommendations” shown the recommendation to take care of for development.

Seven “Appendix” Describe The alternative system that we presented at the beginning of the project and components used in the project.

Eight “References” show all the references that use in the project.

1.11 Timeline:

The Time that takes from us to collect and process all the data in 1st semester weeks in table 1.1.

Table 1.1 Timeline

Process	Weeks															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Collecting data and Literature	/	/	/	/	/											
Analyzing data				/	/	/	/	/								
Modeling							/	/	/	/	/	/				
Simulation												/	/	/		
Writing the documentation						/	/	/	/	/	/	/	/	/	/	
First Presentation																/

1.12 Project Budget

The budget of the project also includes printing costs and local study and survey. The table shows the estimated cost of each one and if it available in Palestine or not.

Table 1.2 Project Budget

Element	Availability	Cost (NIS)
Internet IP domain / year	yes	50
Internet Router.	yes	400
Electrical Pump Motors.	yes	1200
Electrical Curtain Motor	yes	100
Electrical Fan Motor	yes	100
Electrical Shelter Motor	yes	100
Valve	yes	400
Relays	yes	7 X 15
Flow Sensor	yes	50
Level Sensor	yes	45
Temperature Sensor	yes	2 X 15
Humidity Sensor	yes	2 X 15
Light Sensor	yes	2 X 15
Soil Sensor	no	120
pH Sensor	no	300
Wires	yes	200
Power supply High voltage	yes	MU supplement
Power supply Low voltage	yes	4 X 30
IoT Controller 1 D1 Mini WeMos	no	2 X 85
IoT Controller 2 ESP 32 WROOM	no	2 X 85
IoT Controller 3 ESP01 X 4 Relays	no	3 X 85
Smartphone	yes	600
Cayenne Server	yes	Free
Total Cost		4455

1.13 Literature review

Smart IoT Farming, is mostly used to denote the application of IoT solutions in agriculture. By using IoT sensors to collect environmental and machine metrics, farmers can make informed decisions, and improve just about every aspect of their work from livestock to crop farming. by using smart agriculture sensors to monitor the state of crops, farmers can define exactly how many pesticides and fertilizers they have to use to reach optimal efficiency. The same applies to the smart farming definition. Farming has seen a number of technological transformations in the last decades, becoming more industrialized and technology-driven. By using various smart agriculture gadgets, farmers have gained better control over the process of raising livestock and growing crops, making it more predictable and improving its efficiency. The need to transmit data between many agricultural facilities still poses a challenge for the adoption of smart farming. The connection between these facilities should be reliable enough to withstand bad weather conditions and to ensure non-disruptive operations. [6]

The Benefits of smart farming of how's IoT shaping agriculture.

Technologies and IoT have the potential to transform agriculture in many aspects:

- ❖ Data, tons of data, collected by smart agriculture sensors, weather conditions, soil quality, crop's growth progress or cattle's health. This data can be used to track the state of your business in general as well as staff performance, equipment efficiency.
- ❖ Better control over the internal processes and, as a result, lower production risks. The ability to foresee the output of your production allows you to plan for better product distribution. If you know exactly how much crops you are going to harvest, you can make sure your product won't lie around unsold.
- ❖ Cost management and waste reduction thanks to the increased control over the production. Being able to see any anomalies in the crop growth or livestock health, you will be able to mitigate the risks of losing your yield.
- ❖ Increased business efficiency through process automation. By using smart devices, you can automate multiple processes across your production cycle, e.g. irrigation, fertilizing, or pest control.
- ❖ Enhanced product quality and volumes. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.

As a result, all of these factors can eventually lead to higher revenue. [6]

In Palestine Polytechnic University a project by Using Computer Vision for Plant Disease Detection based on image processing techniques, 2013 that can detect the infected plants using color and texture information appearing on plant leaves, and concluded that a computer based method that can read a captured image of a plant leaf and give a statement and numbers that describes infection of this leaf from the image with minimum user intervention is innovated, and but their future developments that using sensors to check external effects and conditions such as humidity and temperature, in order to predict the occurrence of diseases before occurring. [7]

So, our project has an IoT system that using sensor with second by second checking system.

The Internet of Things (IoT) refers to the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. IoT is expected to spread rapidly over the coming years and this convergence will unleash a new dimension of services that improve the quality of life of consumers and productivity of enterprises.

For consumers, the IoT has the potential to deliver solutions that dramatically improve energy efficiency, security, health, education, and many other aspects of daily life. For enterprises, IoT can underpin solutions that improve decision-making and productivity in manufacturing, retail, agriculture, and other sectors.

In Palestine Polytechnic University a project by Using VFD in Pumping System SCADA, 2013, that main purpose was to Supervisory control and data acquisition (SCADA) solutions provide a base for more reliable operation of water systems and significant operating and financial benefits, both, which are important to utility management. they provide means for increased productivity, reducing the number of failure events, reduced losses due to damages and minimal losses of potable water. System parameters, which are communicated via Ethernet network present true conditions, and commands sent from SCADA centrals to remote sites that are aimed to achieve optimal, reliable, and safe operation. [8]

One of the important recommendations is to have an GPRS Communication to control the System in the far area, we have been discussed three types of internet access connectivity, the other recommend was to make sure that the system is secure and it is visible to design and implement rules for access control and sharing of data like implement firewalls and special people can access to the program, our project is full secured for the user by platform authentications.

Technological change has been the major driving force for increasing agricultural productivity and promoting agriculture development. In the past, the choice of technologies and their adoption was to increase production, productivity, and farm incomes. Over many decades, policies for agriculture, trade, research and development, education, training, and advice have been strong influences on the choice of technology, the level of agricultural production, and farm practices. Today, farmers, advisors, and policymakers are faced with complex choices. They are faced with a wide range of technologies that are either available or under development; they must deal with the uncertainties of both the effects these new technologies will have throughout the agri-food chain and the impact that a whole range of policies will have on the sustainability of farming systems. Besides, there is increasing pressure on agricultural research and advisory budgets that must be accommodated. [3]

The Internet of things refers to a type of network to connect anything with the Internet-based on stipulated protocols through information sensing equipment to conduct information exchange and communications to achieve smart recognitions, positioning, tracking, monitoring, and administration. In this paper, we briefly discussed what IoT is, how IoT enables different technologies, about its architecture, characteristics & applications, IoT functional view & what are the future challenges for IoT. Internet of things (IoT) is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. With the Internet of Things, communication is extended via the Internet to all the things that surround us. The Internet of Things is much more than a machine to machine communication, wireless sensor networks, sensor networks, 2G/3G/4G, GSM, GPRS, RFID, WI-FI, GPS, microcontroller, microprocessor, etc. These are considered as being the enabling technologies that make “Internet of Things” applications possible. [9]

2 Chapter Two Conceptual Design and Functional Specification

- 2.1 Overview
- 2.2 Needs and Requirement
- 2.3 Shape and Dimension Selection
- 2.4 Irrigation Design
- 2.5 Proposed Designs
- 2.6 Block Diagram
- 2.7 Specification

2.1 Overview

This chapter will separate the system to subsystems and will present the suggested design for every subsystem and describe the conceptual design of the project taking into consideration the requirements and objectives, and it describes the functional specification of the component and the integration between them.

2.2 Needs and Requirement

Agriculture in Palestine suffers from several problems related to the availability of water and efficient use of the available farmlands, and this difficulty comes from the political and economic situation, that's why there' to think of an alternative solution to use suitable resources efficiently.

1. Increased irrigation efficiency.
2. The ability to control some factors affecting the agricultural process.
3. Able to control and monitor from smartphones.
4. The system should be safe and user friendly.
5. It can be added to any existing facility.
6. Costs do not exceed 5,000 dollars.

2.3 Shape and Dimension Selection

There's no real standard size and shape for greenhouses, but there are many different types in many different dimensions. [8] [9]

The selection of the design depends on Nature of climate, Cost, Available material and Temporary or permanent use.

So, we choose the dome design where It is the most widely used in Palestine and it is Suitable for its climate and it is cheap and consists of available material and it is allowed to be permanent such in figure 2.1. [10]



Figure 2.1 Regular Flat Arch familiar shapes of the greenhouses in Palestine

2.4 Irrigation Design

In terms of annual rainfall, 60% of the country (Palestine) may be defined as arid or semi-arid. Rain falls only between November and April, with uneven distribution of yearly precipitation, ranging from 28 inches (70 cm.) in the north to less than 20 inches (50 cm.) in the south. [10]

The great challenge for the coming decades is to increase food production with less water, particularly in countries with limited water and land resources various types of irrigation techniques differ in how the water obtained from the source is distributed within the field. In general, the goal is to supply the entire field uniformly with water, so that each plant has the amount of water it needs, neither too much nor too little.

Figure 2.1 shows how the waste of water by splashing water all over the place.



Figure 2. 2 water irrigation waste method by splashing water [10]

While surface irrigation methods rely on watering the whole surface of the field and overhead irrigation leaves the plants wet and produces runoff, drip irrigation is far more controlled. Water is slowly provided to a very specific area close to the plant, by a network of drip emitters. The advantage of using trickle or drip irrigation simply controls. This method of irrigation is precise and economical.

A drip emitter is rated in gallons per hour. The flow of water is so slow that it is easily absorbed into the ground. Figure 2.3.

In a well-tuned system, there is little opportunity for excess water running off and being wasted.

The drip irrigation system has reduced water consumption by 50-70 percent compared with surface irrigation, and by 10-20% compared to sprinkler irrigation.

Depending on the above, drip irrigation is used, since it is an efficient method for water conservation, healthy plants, and saving money. Therefore, as is customary in drip irrigation, it is used in greenhouses, with all calibration and specifications.

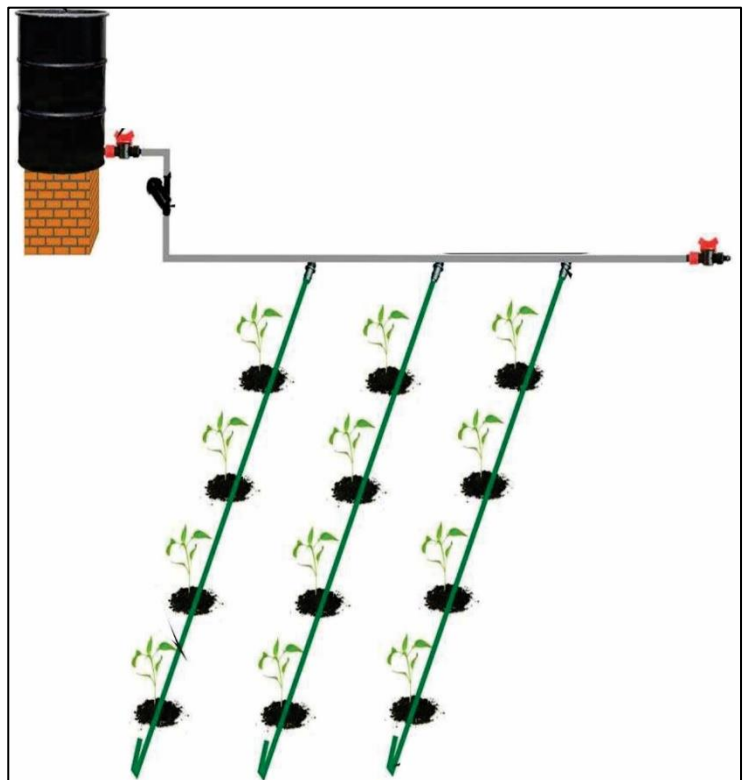


Figure 2. 3 drop water irrigation method

2.5 Proposed Designs

This design proposed to use node MCU ESP-8266 which all electric components (see in Chapter 1.9) in the greenhouse connect with secondary ESP unit which read sensors signals and then send the signals to main ESP by Wi-Fi technology.

The relationships and all components are cleared in the figure 2.4.

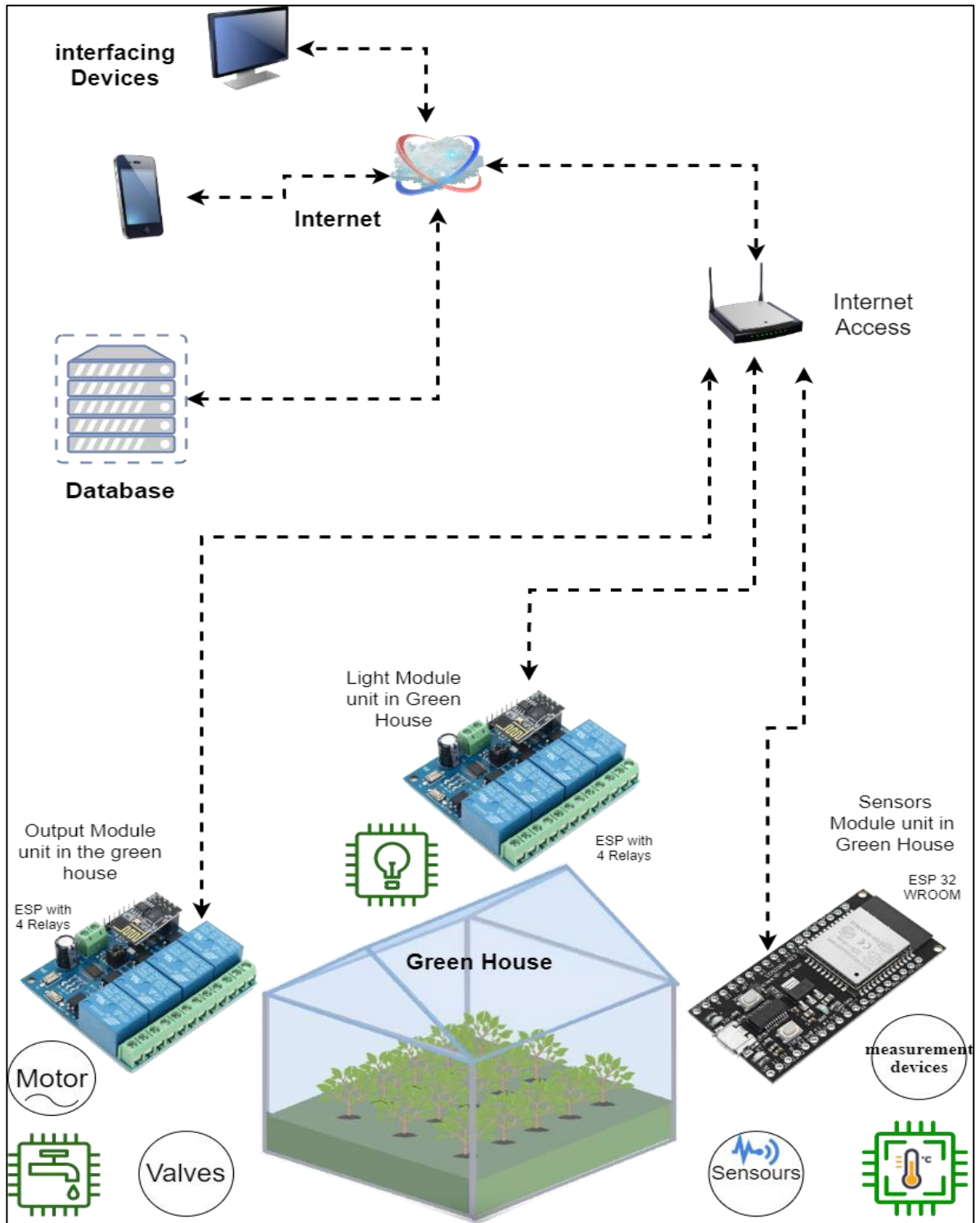


Figure 2.4 Proposed Design

2.6 Block Diagram

The First block figure 2.5 that consists of the main bond of the process that is an interface diagram contains the database and smartphones and interfacing devices connects to Cayenne sever.

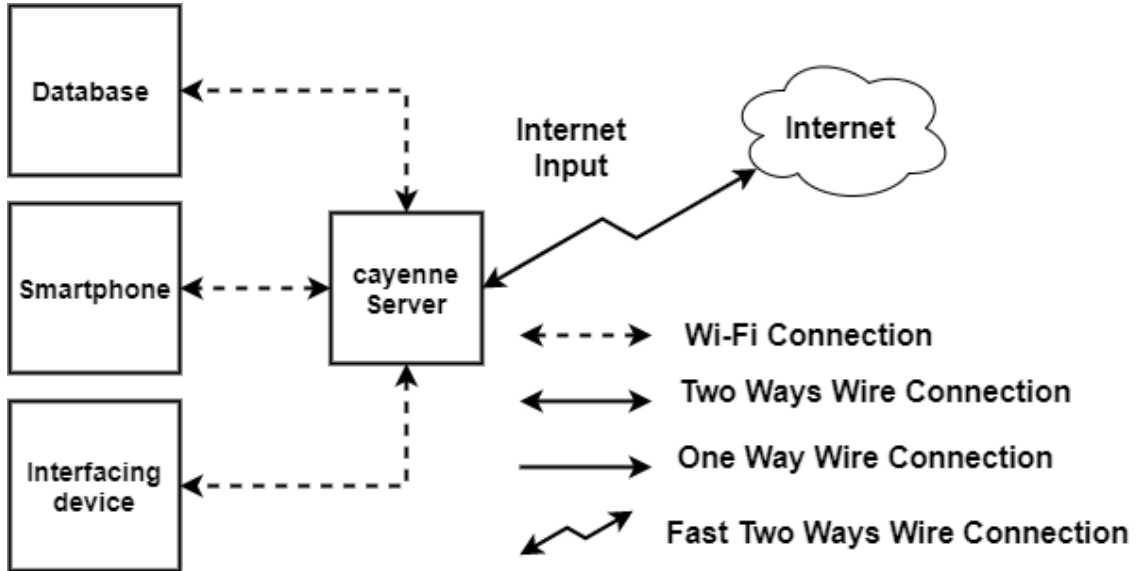


Figure 2.5 Block of interfaces diagram and Connection symbols

The Second block figure 2.6 contains IoT controller 1 as ESP8266 on WeMos D1 mini-module with connected gadgets: Level sensors as an Ultrasonic level sensor and Water flow sensor.

And shows the processing unit in the controller that will manage all signals

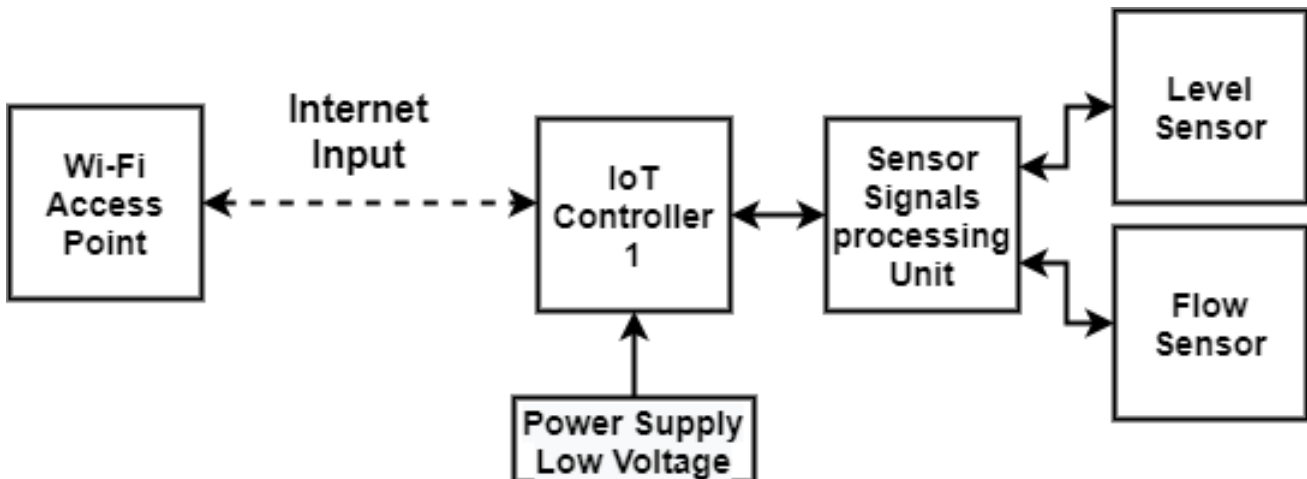


Figure 2.6 Block of IoT controller 1 with connected gadgets

The Third block figure 2.7 contains IoT controller 2 as ESP32 WROOM module with connected gadgets: Light Sensors, Humidity Sensor, Temperature Sensor, and Rain Sensor.

And shows the processing unit in the controller that will manage all signals.

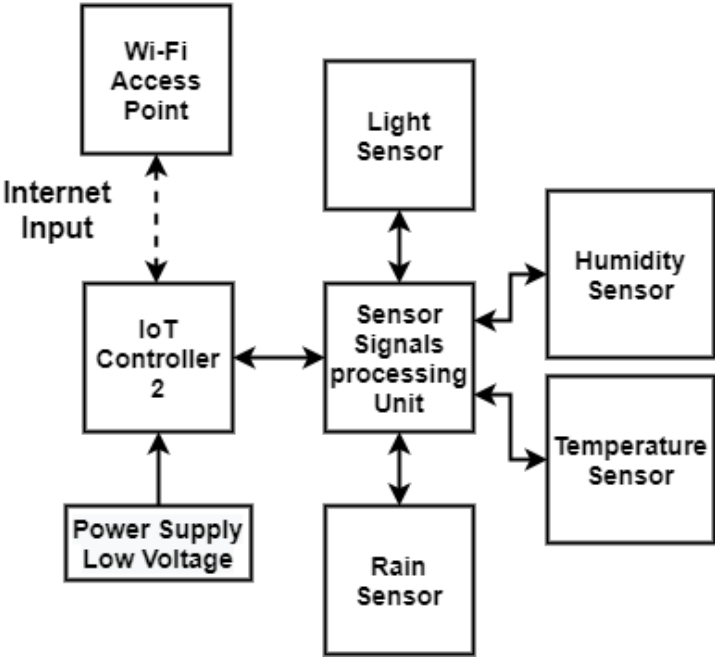


Figure 2.7 Block of IoT controller 2 with connected gadgets

The Fourth block figure 2.8 contains IoT controller 3 as ESP01 with connected gadgets that control outputs: Lights relays, Fan motor relays, and Shutter motor relays' open or close.

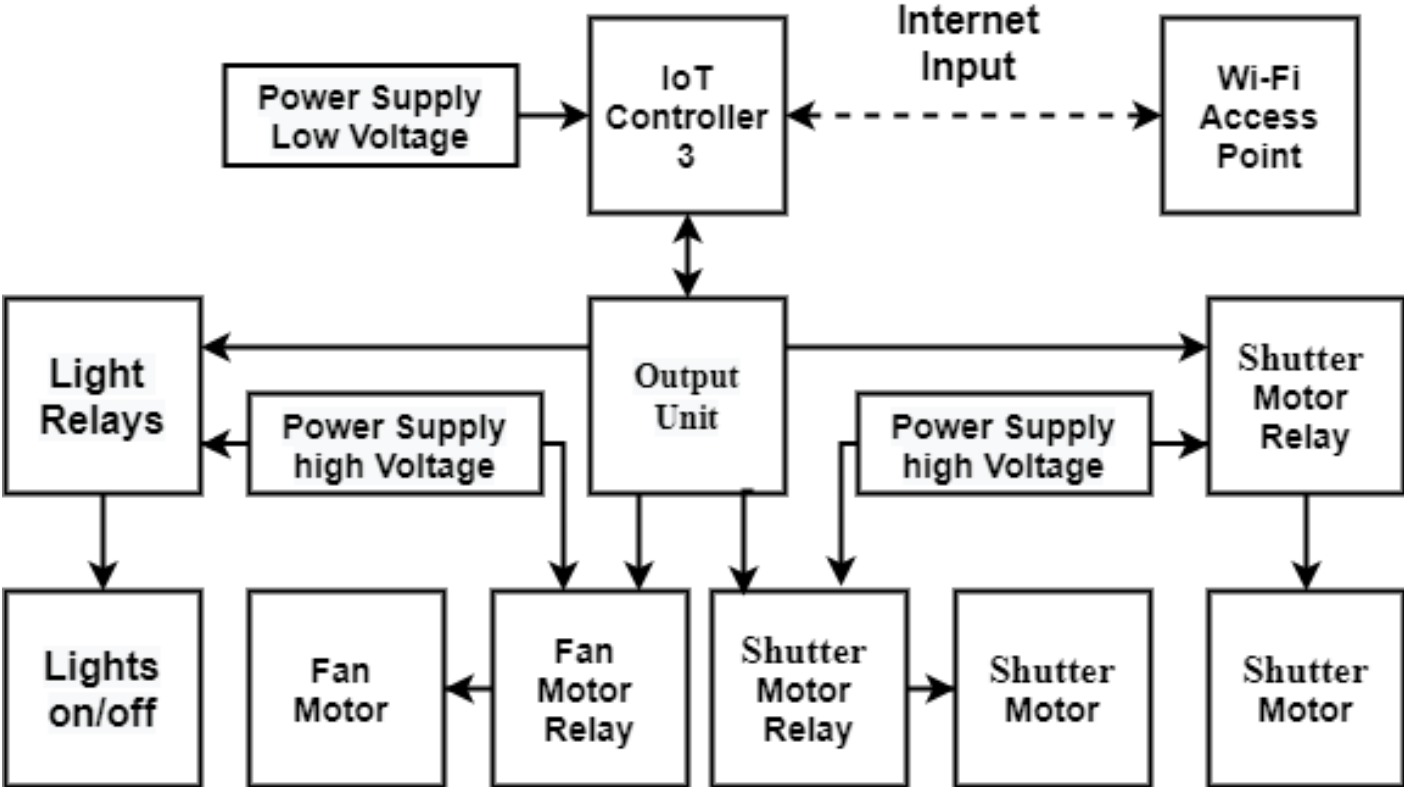


Figure 2.8 Block of IoT controller 3 with connected gadgets

The Fifth block figure 2.9 contains IoT controller 4 as ESP8266 on WeMos D1 mini-module with connected gadgets: Humidity Sensor, Temperature Sensor, and Soil Moisture Sensor.

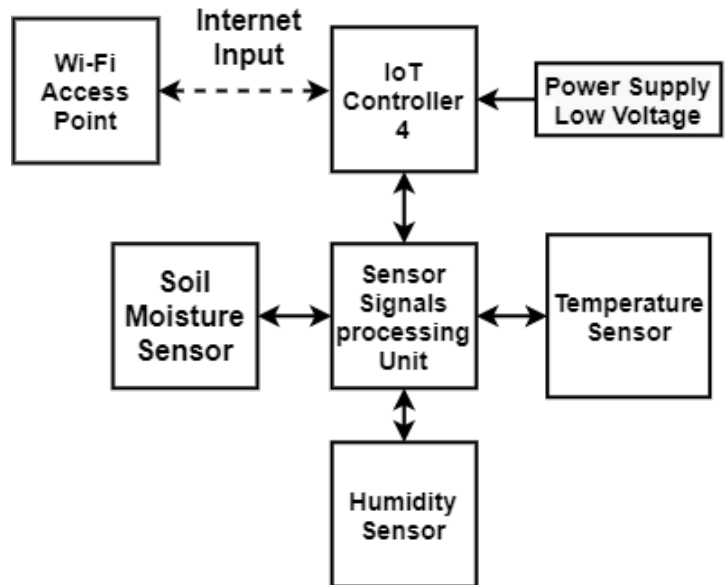


Figure 2.9 Block of IoT controller 4 with connected gadgets

The Sixth block figure 2.10 contains IoT controller 5 as ESP01 with connected gadgets that control outputs: valve relays, Water pump motor relays, and Compost Pump motor relays.

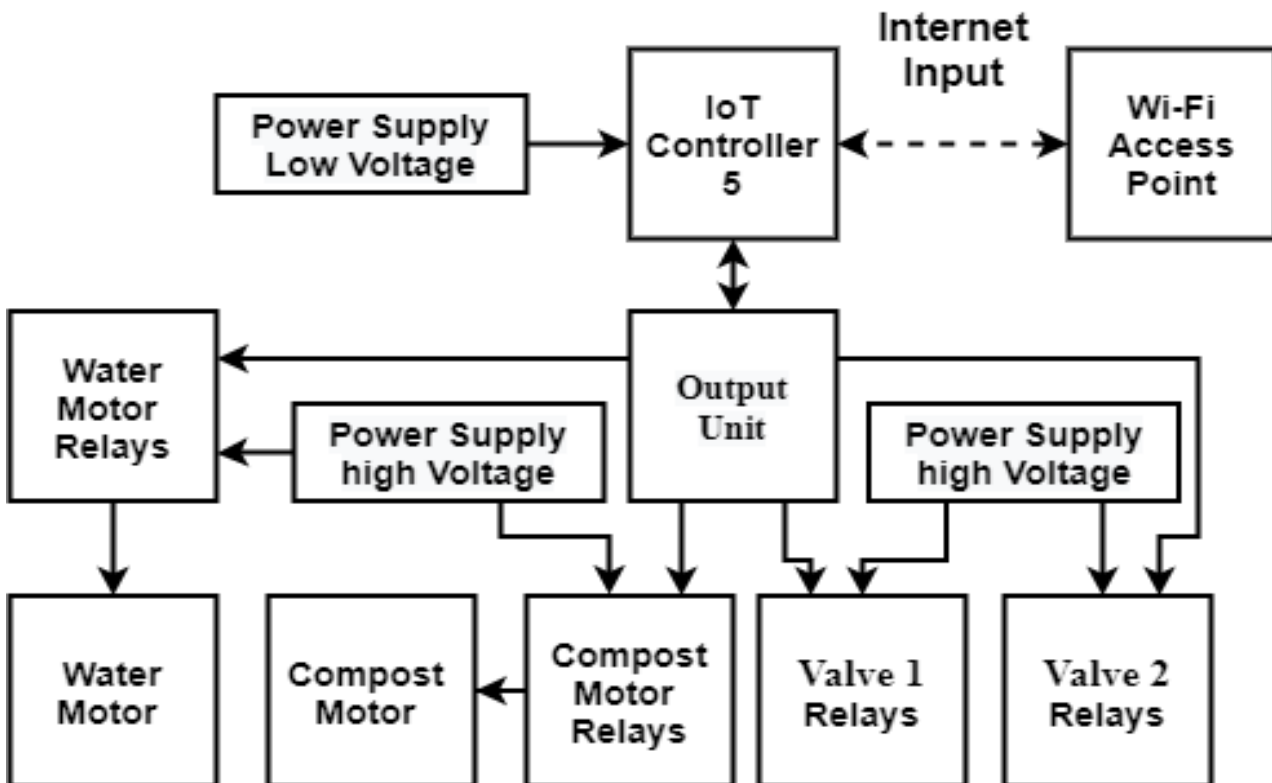


Figure 2.10 Block of IoT controller 5 with connected gadgets

The Seventh block figure 2.11 contains IoT controller 6 as ESP32 WROOM module with connected gadgets: Light Sensors, Humidity Sensor, Temperature Sensor, pH sensor, and Soil Moisture Sensor.

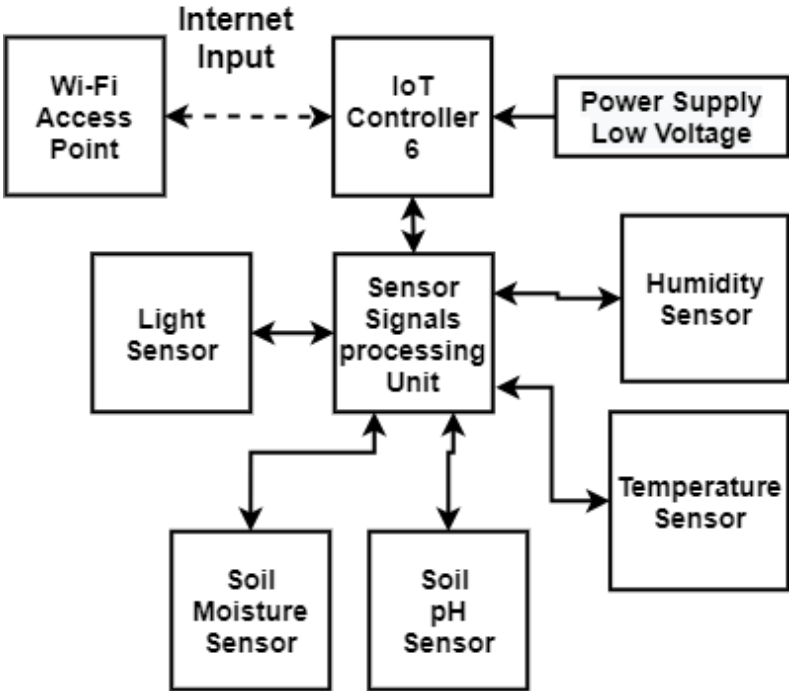


Figure 2.1 Block of IoT controller 6 with connected gadgets

The Eighth block figure 2.12 contains Extension IoT controller 7 as ESP01 with connected gadgets that control outputs made for any future devices relays.

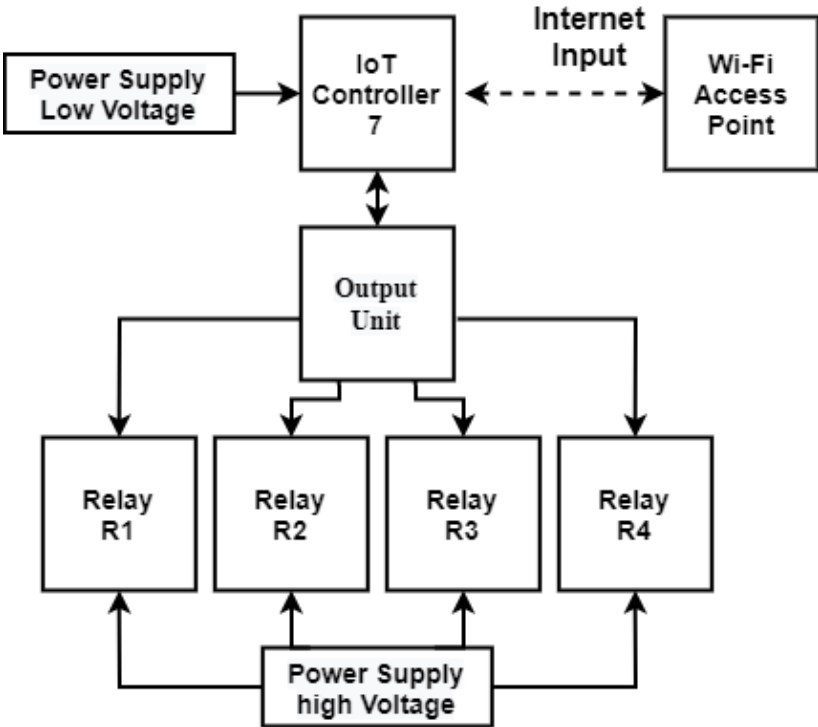


Figure 2.2 Block of IoT controller 7 with connected gadgets

Then all these blocks are connected to the internet through the Wi-Fi Connection and implement the project and become one big block figure 2.13.

All the gadgets that are used from the IoT controllers, sensors, motors, and relays are specified in part name and number of parts with Description and Function in table 2.1

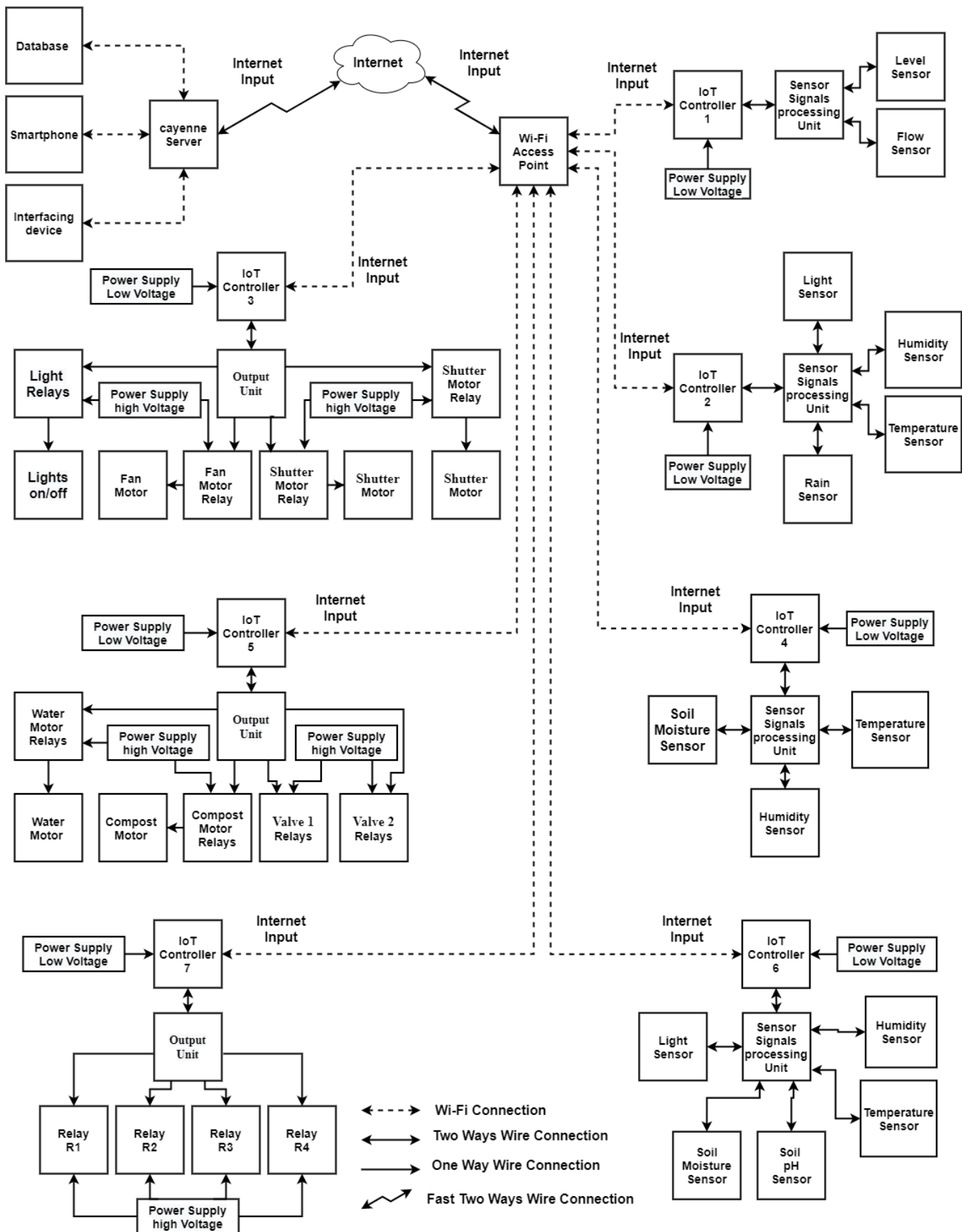


Figure 2.3 One Big Block Diagram that contains all Gadgets together

2.7 Specification

Table 2.1 Specifications

Part Name	#of parts	Description	Function
Fan Motor	1	Single-phase induction, 0.5 hp	For the air window Shelter
Shelter Motor	1	Single-phase induction, 0.5 hp	Used to create flow within a fluid
Pump Motor	1	Single-phase induction, 1 hp	To pump water and fertilizers to the plant
Valve	2	24 V Water 15mm	Liquid Switch for flow controls
Relays	7	5 V coil – 220V Common - NO	To manage the electrical Switching
Flow sensor	1	Digital output	Senses the water flow in the pipelines.
level sensor	1	Digital output	Senses the water in the tank.
Temperature Sensor	2	DHT11	Senses the entire temperature of the greenhouse
Humidity sensor	2	DHT11	Measures both moisture and air temperature
Light Sensor	2	TSL250R	Senses the sunlight, or environment light
Soil Moisture Sensor	1	Analog output	Senses the soil moisture
pH Sensor	1	Analog output	Senses the pH value in the soil between acidic or basic ranges
Power supply High voltage	3	220 V	To provide power to the Relays.
Power supply Low voltage	4	5 V	To provide power to the MCU's.
IoT Controller 1	1	ESP 32 WROOM	To control the light switch and read Temperature, humidity, light, soil Moisture, pH sensors in the soil
IoT Controller 2	1	ESP 8266	To control the light switch and read Temperature, humidity and light sensors in the air
IoT Controller 3	1	ESP with 4 Relays	To control the pump Motors and Valves switch and read Flow and Level sensors

IoT Controller 4	1	ESP with 4 Relays	To control the Fan, Shelter and Curtain Motors
Smartphone	-	Android or IOS	For interconnection between the user and system platform
Interfacing device	-	Android or IOS	For interconnection between the user and system platform
Cayenne Server	-	Cayenne Co. System	Holds the platform of the system
Database	-	Local computer	To store the parameters
Internet	-	Internet	Connectivity of the data.

3 Chapter Three Electrical Design

3.1 Overview

3.2 Fan

3.3 Water Pump

3.3 Sensors

1 Level sensor

2 Flow rate sensor

3 pH level in the soil sensor

4 Light Sensor

5 Soil moisture Sensor

6 Rain Drop Sensor

7 Humidity & Temperature Sensor

3.4 Controllers and IoT Devices

3.5 Relays

3.6 Contactors

3.7 Electrical protection and isolation circuits

3.1 Overview

This chapter will discuss electric components that used in the project, by considering a Criteria, Definitions, location, calculations and the reason of the engineering choice:

- Fans
- Sensors
- Controllers
- Relays
- IoT Devices

3.2 Fan

A Fan device have been chosen to make an air flow throw the prototype.

A Fan is a powered machine used to create flow within a fluid, typically a gas such as air. A fan consists of a rotating arrangement of vanes or blades which act on the air. Figure 3.1.

Fan Selection Criteria:

1. Fan diameter.
2. ACFM - Airflow required for design heat transfer duty.
3. ASP - Actual static pressure from the sum of all resistances to airflow.
4. Air temperature at the plane of the fan.
5. Fan elevation above mean sea level or air density at fan.
6. Fan speed in either tip (FPM) or rotational speed (RPM).



Figure 3.1 The Fan used

In the simplest case, design airflow, static pressure, and density are calculated for the fan “curve” conditions at 12,000 FPM tip speed and standard density with no noise limitations. The operating point is then plotted on a fan curve of the appropriate diameter. The fan curve shows the correct pitch angle and horsepower required by the fan at the design point.

A 1140 RPM Fan were chosen that can handle the air flow density with prototype diminution.

CFM Calculation:

$$A_F \times L = V \quad 3.1$$

$$A_F = w \times h_{wall} + (r - h_r) - r^2 \times \pi \times \frac{\theta}{360} \quad 3.2$$

$$\theta = \sin^{-1}\left(\frac{\frac{1}{2}w}{r}\right) \quad 3.3$$

$$CMF = v \div t \quad 3.4$$

Where:

A_F : Area of a front view

L : The length of the greenhouse

w : Wide of greenhouse

h_{wall} : Walls' height of the greenhouse

V : The volume of the greenhouse

r : Radius of the roof

h_r : Roofs' height of the greenhouse

θ : Angel of Circular sector

t : Time in minute needed to exchange air

Axial flow fan:

An axial fan is a type of compressor that increases the value of pressure of the airflow through it. Blades of the axial-flow fans force all air to move parallel to the shaft about which the blade rotates.

Location of the fan:

The exhaust fans should be placed on one of the shorter walls with the bottom of the fan located approximately 3 ft. from floor level. The shutters should be placed on the opposite wall at approximately the same height. This allows the cool airflow to pass directly over crops placed at bench height. Under wintertime cooling conditions (high sunlight, low outdoor temperature), it is

recommended to have a small inlet shutter placed high on the gable end wall opposite the exhaust fan. This allows the cold incoming air to mix with the warmer greenhouse air before being drawing across plants or crops. This shutter would replace the normal inlet shutters used during summertime cooling.

The Fan location is placed in the second quarter of prototype to achieve the air all over the soil.

3.3 Water Pump

A Water Pump is a device that hoover vacuum the water in the input then spread it to the output, Figure 3.2.

Reason of use this device, first the water flow value of 0.7 bar throw the pipes, second the compatible with small water tanks, third power source of 220 volts 50 Hz.

the water pump feature is a Solenoid pump delivering a dynamic output of 950 ml water flow at 0.7 bar pressure. This range has a class 2 double insulated system with an integral diode converter, and it's a 2200 VOLT of 32 W that give an 800 cc/min AT 0,5 Bar. [11]



Figure 3.2 Water Pump [11]

3.4 Water Solenoid Valve

Control the flow of fluid using the flow of electrons. Figure 3.3

Reason of use, this liquid valve would make a great addition to robotic gardening project. There are two 1/2" (Nominal non-taped National Pipe) outlets. Normally, the valve is closed. When 220AC is applied to the two terminals, the valve opens and water can push through, its Material is Metal and Plastic, Working pressure 0.02~0.8Mpa.

The valve has a gasket arrangement inside, so there is a minimum pressure requirement of 0.02 Mpa (3 PSI). Also, liquid can only flow one direction.

Features: Moisture-proof and anti-corrosion, Wear-resistant and high temperature resistance, Durable, practical and stable. [12]



Figure 3.3 Water Solenoid Valve [12]

3.5 Sensors

Each parameter needs a sensor to sense its value in our system, to control it.[8]

The parameter:

- Soil humidity
- Air temperature and humidity
- pH in the soil
- Water level
- Water flow rate
- Light
- Rain Status

(1) Ultrasonic Level Sensor

Ultrasonic as a Level Sensors is Continuous level measurement. That sends a radio beam and receive it, then collects the time that the proesses takes then collect the distance. Figure 3.4

Reason of use, first reason is the input voltage 5 volt that can be directly input from the NOD MCU, second reason is the compatible for water and liquids, third reason is the error rate is 10 cm per 5 meters and we need only to measure 30 CM only, forth the compatible signal of the output for the MCU.A float switch is a type of level sensor, a device used to detect the level of liquid within a tank. The switch may be used to control a pump, forth is an energy saver sensor that didn't need a high power to detect water level. [13]

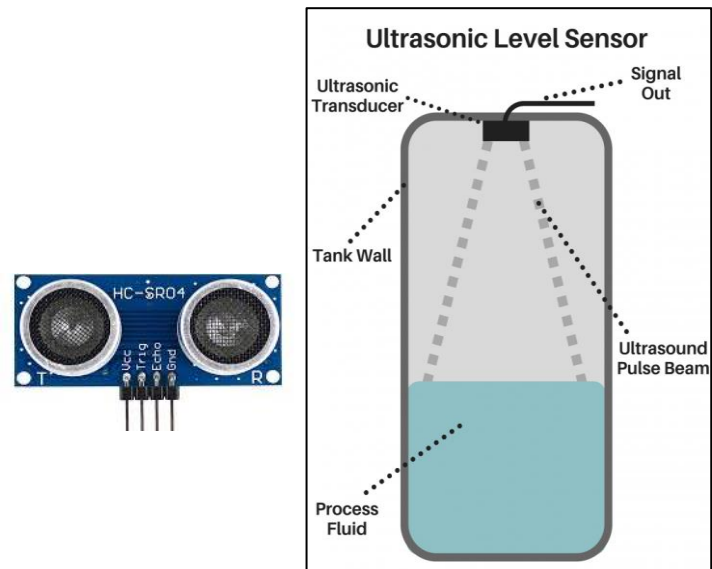


Figure 3.4 Ultrasonic Level sensor and the location site in the tank [13]

(2) Flow Sensor switch

A flow meter (or flow sensor) is an instrument used to measure linear, nonlinear, mass or volumetric flow rate of a liquid or a gas in pipes. Figure 3.5 [14]

Reason of use, first the flow result of on when the water is running or off when water not running so we used a nonlinear flow sensor switch of ON/OFF signal that uses the hall effect principal the output signal can be detect easily by the MCU, second is the volumetric flow rate didn't need for this project since the prototype is feeding whit a 30cm gallon of water on a fixed a pressure water pump. third is an energy saver sensor that didn't need a high power to detect water flow.



Figure 3.5 Flow Sensor Switch [14]

(3) pH level in the soil sensor

Soil can be acid, neutral, or alkaline, according to its pH value. Most plants prefer a pH range from 5.5 to 7.5, but some species prefer more acid or alkaline soils. Nevertheless, every plant requires a particular range of pH, for optimum growth. Figure 3.6 A pH sensor is one of the most essential tools that's typically used for water measurements. This type of sensor can measure the amount of alkalinity and acidity in water and other solutions. [15]

Reason of use, first reason is that this sensor can afford a readable output range to the MCU from 0 to 8 pH degree. second is didn't need a feedback soil to make a comparison test between tow soils, forth is an energy saver sensor that didn't need a high power to detect soil pH.



Figure 3.6 pH level in the soil sensor [15]

(4) Light Sensor

A Light Sensor generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies called “light”, and which ranges in frequency from “Infra-red” to “Visible” up to “Ultraviolet” light spectrum. Figure 3.7 [16]

Reason of use, first it's the most affordable sensor in the market, second the range of light and dark that can detect, third can be connected to an analog to digital module to convert the detected range into a readable range from the MCU. fourth is an energy saver sensor that didn't need a high power to detect light.

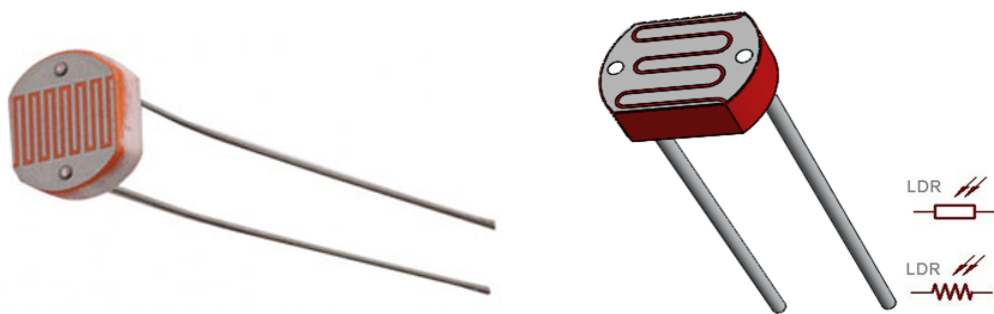


Figure 3.7 Light Sensor [16]

(5) Soil moisture Sensor

Soil Moisture Sensor is a simple breakout for measuring the moisture in the soil and similar materials. Figure 3.8 [17]

Reason of use, first is affordable soil moisture sensor in the market, second can detect the range from 0 to 10 (0-3 Dry, 4-6 Good, 7-10 Wet) soil moisture range through the analog to digital module, third the life time of the sensor is about two years, fourth is an energy saver sensor that didn't need a high power to detect soil moisture.

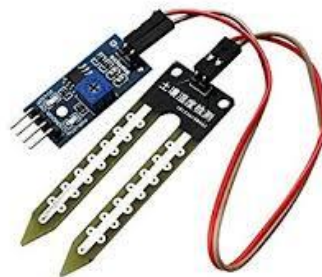


Figure 3.8 Soil moisture Sensor [17]

(6) Rain Drop Sensor

Raindrop Sensor is a tool used for sensing rain. It consists of two modules, a rain board that detects the rain and a control module, which compares the analog value, and converts it to a digital value. The raindrop sensors can be used in the automobile sector to control the windshield wipers automatically, in the agriculture sector to sense rain and it is also used in home automation systems. Figure 3.9 [18]

Reason of use, first its affordable as Rain drop Sensor Module in the market, second Output format: Digital switching output (0 and 1), and analog voltage output AO, third low power consume, forth can be connect to a third part device analog digital module to adjust the sensitivity.

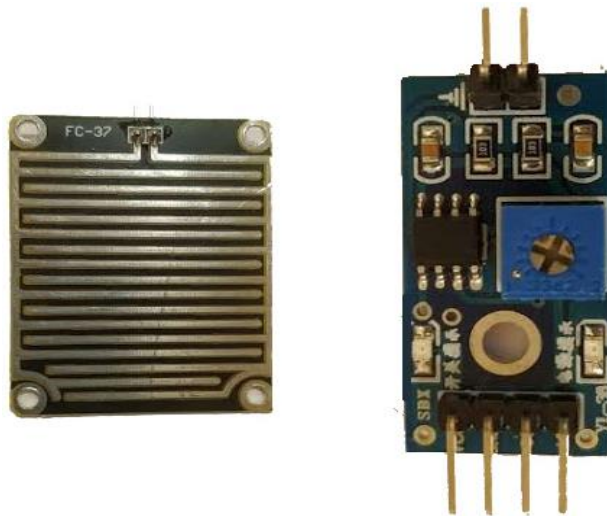


Figure 3.9 Rain Drop Sensor with Analog Digital Module [18]

(7) Humidity & Temperature Sensor

Humidity sensor (or hygrometer) senses, measures, and reports both moisture and air temperature. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity. Relative humidity becomes an important factor for plants. Figure 3.10 [19]

Reason of use, first its affordable as DHT11 in the market, second can detect two ranges one is present of humidity two is the temperatures degree in Celsius, third didn't need to a third part between sensor and MCU, forth is an energy saver sensor that didn't need a high power to detect air temperatures and air humidity.

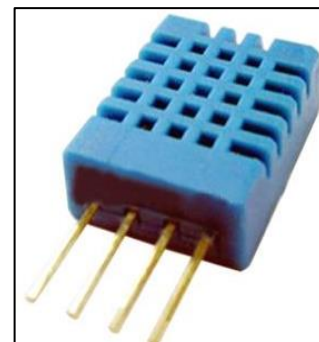


Figure 3.10 DHT 11- Humidity & Temperature Sensor [19]

3.6 Controllers and IoT Devices

- A device used to operate or control a machine.
- IoT device is a microcontroller with Wi-Fi build-in connected to sensors, software, actuators, and computer devices. They are attached to a particular object that operates through the internet, enabling the transfer of data among objects or people automatically without human intervention. [20]
- IoT microcontrollers are programmed in a C++ language and modified by platform systems.
- Reason of use, first it's affordable as ESP 8266, ESP32, and ESP01 (Figure 3.11-3.13) in online markets, second can be programmed in Arduino IDE using C ++ language, third the Wi-Fi range is 100 meters in radio spherical shape coverage, fourth is an energy saver controller that didn't need a high-power consumption.

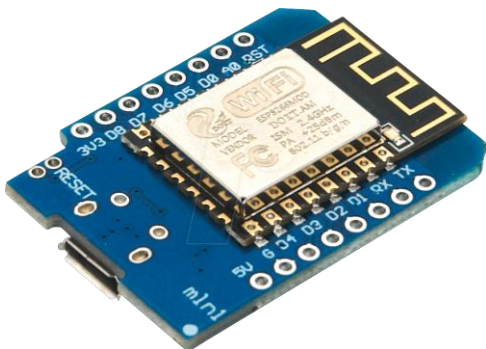


Figure 3.13 IoT Controller ESP 8266 D1 MINI [20]

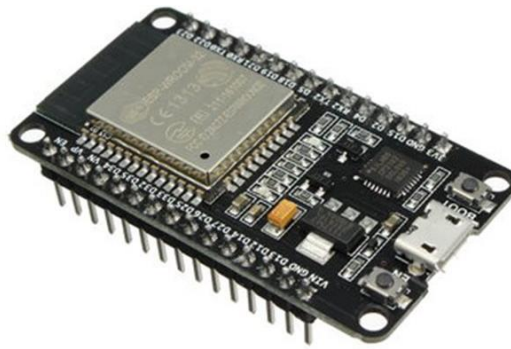


Figure 3.12 IoT Controller ESP 32 [20]

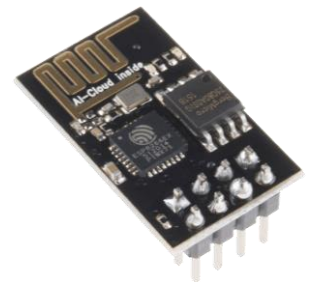


Figure 3.11 IoT Controller ESP 01 [20]

3.7 Relays

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as making contacts, break contacts. Figure 3.15 – 3.14 [21]

Reasons of use, first it's affordable as a relay module in the market, second the mission of trans signal between low power to high power, third easy to maintains.



Figure 3.15 Relays [21]

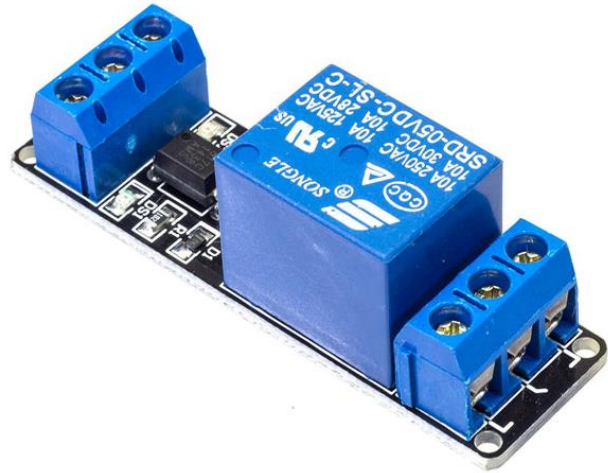


Figure 3.14 Relays with Optocoupler circuit [21]

3.8 Analog Digital Sensor Module

The Analog Digital Sensor Module is a third part device places between a controller and a sensor that can minimize the range of the sensor into a readable size for controller. Figure 3.16 [18]

Reason of use, it's the best tool to get the all the ranges of the sensors, and the affordable in market, and low power consume.

A Modules reach the set threshold, DO port output high when soil moisture exceeds a set threshold, the module DO output low. Digital outputs D0 small plates can be directly connected with the microcontroller through the microcontroller to detect high and low. Small plates digital output DO OUR relay module can directly drive the buzzer module, which can be composed of a soil moisture alarm equipment. Small plates AO analog output modules can be connected and AD through the AD converter, you can get a more accurate value of soil moisture. [18]

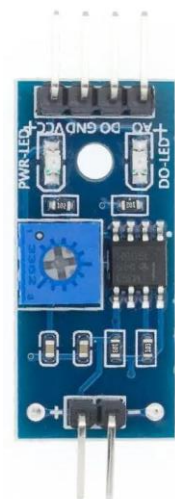


Figure 3.16 Contactor [18]

3.9 Electrical protection and isolation circuits

Opto-coupler:

An Opto-isolator (also called an optocoupler, photocoupler, or optical isolator) is an electronic component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. Figure 3.17 [22]

Reason of use Outputs' ESP 8266 MCU must be protected from high voltage, so we will add optocoupler.

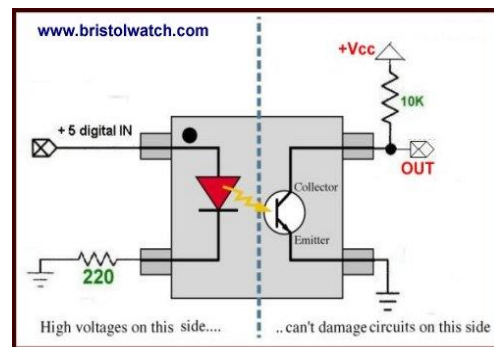


Figure 3.17 Opto-coupler Circuit [22]

3.10 Electrical Power Source

DC Batteries Figure 3.18 used to supply the power to the DC Low voltage components [23] such as Node MCU, and it has a lot of advantages that are:

- Available in all standard sizes.
- High power density.
- Easy to recharge.
- A good alternative to alkaline which has almost all similarities and also it is rechargeable.

Reason of use, First the affordable in market, second high-power efficiency, third available in 5 volts, fourth can be nine days powered up the devices, fifth it can be fast charged in a short time period.



Figure 3.18 Ni-MH batteries [23]

4 Chapter Four Software Design

- 4.1 Introduction
- 4.2 System Layout
- 4.3 System Main Parts
 - 4.3.1 ESP 8266 Wi-Fi Microcontroller
 - 4.3.2 ESP WROOT 32 Wi-Fi Microcontroller
 - 4.3.3 ESP WITH 4 Relay - ESP 8266 E01 4 channel Wi-Fi Microcontroller
 - 4.3.4 Database
 - 4.3.5 Internet Access
 - 4.3.6 Sensors and measurement devices
 - 4.3.7 Electrical Motor and liquid valves devices
 - 4.3.8 Platform and System Application
- 4.4 Connectivity principles
- 4.5 The ALGORITHM SYSTEM

4.1 Introduction

Depending on the idea of using the advanced industrial smart parts because they are more reliable and easier to deal by taking advantage of their software features and Internet transport and the possibility of rapid modification and accelerated high response. Internet access points and Node MCU’s controller that support input and output modules for analog and digital signals connected to sensing and measurement devices, electrical valves, and water pump devices, with external system application and external system database with cloud platform system. [6]

4.2 System Layout

The Internet expresses the link between the project layout gadgets layout gadgets and connects the database with the vendor system and controllers. Figure 4.1

- 1. ESP 8266 D1 mini Wi-Fi IoT Microcontroller.
- 2. ESP WROOT 32 Wi-Fi IoT Microcontroller.
- 3. ESP WITH 4 Relay - ESP 8266 E01 4 channel Wi-Fi IoT Microcontroller.
- 4. Database.
- 5. Internet Access.
- 6. Sensors and measurement devices.
- 7. Electrical Motor and liquid valves devices.
- 8. Platform and System Application.

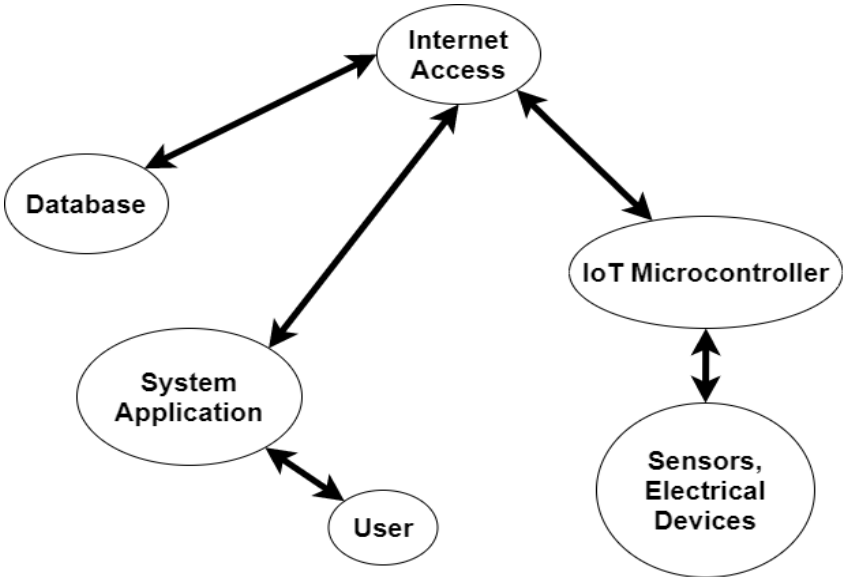


Figure 4.1 System layout Scheme

4.3 System Main Parts

(1) ESP 8266 Wi-Fi Microcontroller

The ESP8266 is the name of a microcontroller designed by Espressif Systems. The ESP8266 itself is a self-contained Wi-Fi networking solution offering as a bridge from the existing microcontroller to Wi-Fi and is also capable of running self-contained applications.

This module comes with a built-in USB connector and a rich assortment of pin-outs. With a micro USB cable, you can connect NodeMCU devkit to Computer and flash it without any trouble, just like Arduino. It is also immediately breadboarding friendly. It's an open-source development board and firmware Wi-Fi module, able to program with the simple and powerful LUA programming language or Arduino IDE.

Reason of use, ESP 8266 have been chosen because it has a variety of specification that achieve the project purpose such as:

- Voltage: 3.3V.
- Wi-Fi Direct (P2P), soft-AP.
- Current consumption: 10uA~170mA.
- Flash memory attachable: 16MB max (512K normal).
- Integrated TCP/IP protocol stack.
- Processor: Tensilica L106 32-bit.
- Processor speed: 80~160MHz.
- RAM: 32K + 80K.
- GPIOs: 17 (multiplexed with other functions).
- Analog to Digital: 1 input with 1024 step resolution.
- +19.5dBm output power in 802.11b mode
- 802.11 support: b/g/n.
- Maximum concurrent TCP connections: 5.
- Can be program in C++ by Arduino IDE

Using Arduino IDE

The most basic way to use the ESP8266 module is to use serial commands, as the chip is a Wi-Fi/Serial transceiver.

However, this is not convenient. using the very cool Arduino ESP8266 project is recommended, which is a modified version of the Arduino IDE. This makes it very convenient to use the ESP8266 chip as will be using the well-known Arduino IDE.

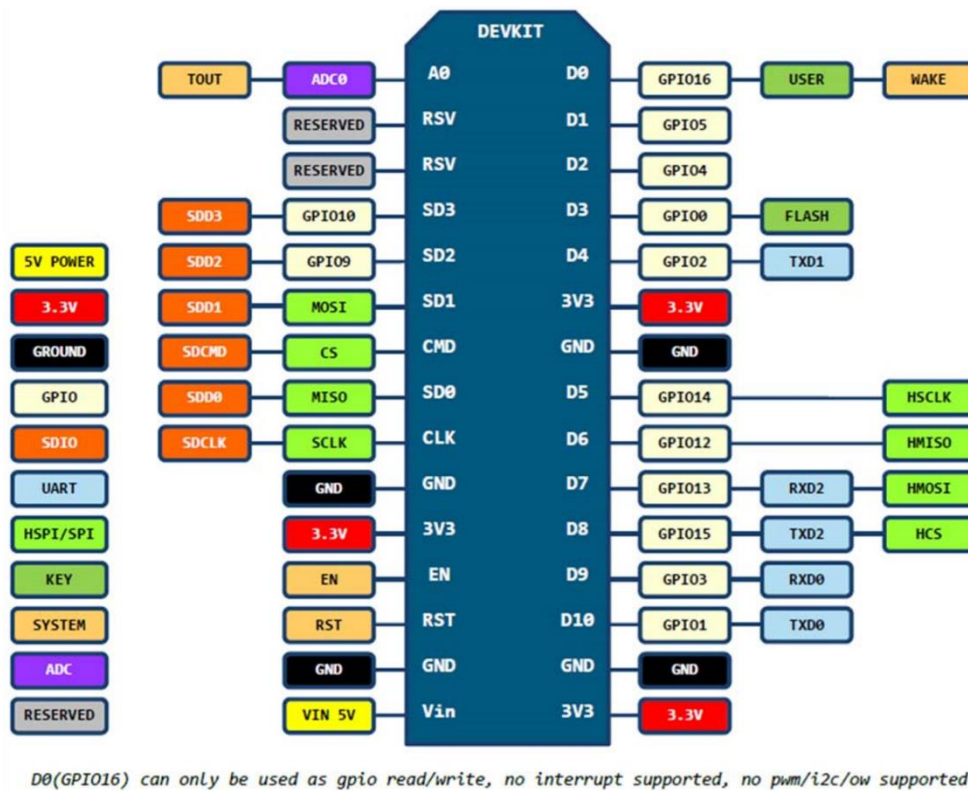


Figure 4.2 Definition and Layout Nude MCU – ESP 8266

A two D1-WeMos-R1-mini MCU’s have been chosen with ESP8266 build-in chip in it.

(2) ESP WROOM 32 Wi-Fi Microcontroller

ESP32-WROOM-32 is a powerful, generic Wi-Fi + BT + BLE (Bluetooth Low Energy) MCU module that targets a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming, and MP3 decoding.

At the core of this module is the ESP32-D0WDQ6 chip*. The chip embedded is designed to be scalable and adaptive. Two CPU cores can be individually controlled, and the CPU clock frequency is adjustable from 80 MHz to 240 MHz, the user may also power off the CPU and make use of the low-power co-processor to constantly monitor the peripherals for changes or crossing of thresholds. ESP32 integrates a rich set of peripherals, ranging

from capacitive touch sensors, Hall sensors, SD card interface, Ethernet, high-speed SPI, UART, I²S, and I²C.

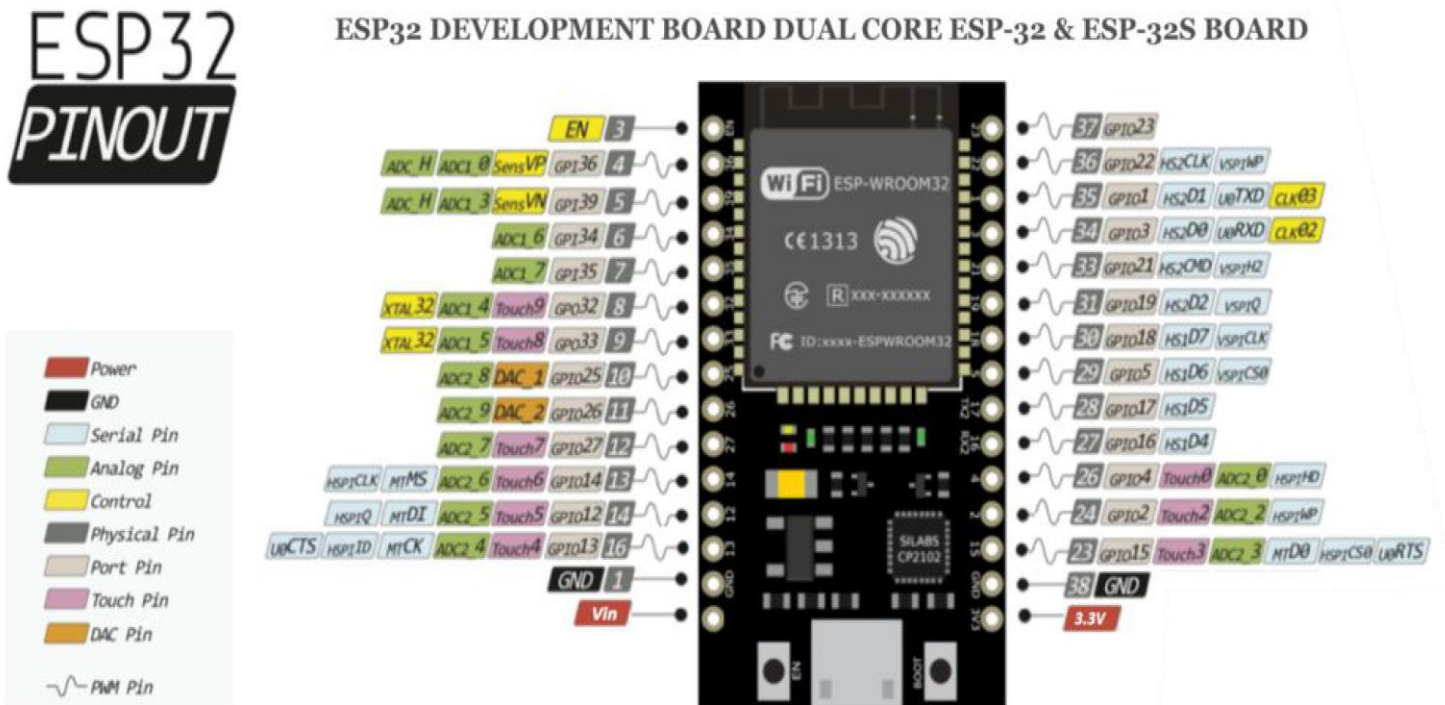


Figure 4.3 Pin Definition and Layout ESP WROOT 32

Reason of use, ESP 32 have been chosen because it has a variety of specification that achieve the project purpose such as:

- Wi-Fi Protocols: 802.11 b/g/n (802.11n up to 150 Mbps), A-MPDU and A-MSDU aggregation and 0.4μs guard interval support Frequency range: 2.4 GHz ~ 2.5 GHz.
- Bluetooth Protocols: Bluetooth v4.2 BR/EDR and BLE specification.
- Radio: NZIF receiver with -97 dBm sensitivity, Class-1, class-2, and class-3 transmitter, AFH.
- Audio CVSD and SBC.
- Module interfaces SD card, UART, SPI, SDIO, I2C, LED, PWM, Motor PWM, I2S, IR, pulse counter, GPIO, capacitive touch sensor, ADC, DAC.
- On-chip sensor Hall sensor.
- Integrated crystal 40 MHz crystal.
- Integrated SPI flash 4 MB.

- Operating voltage/Power supply 3.0 V ~ 3.6 V.
- Operating current Average: 80 mA.
- Minimum current delivered by a power supply 500 mA.
- Recommended operating temperature range $-40\text{ }^{\circ}\text{C} \sim +85\text{ }^{\circ}\text{C}$.
- Package size $(18.00\pm 0.10)\text{ mm} \times (25.50\pm 0.10)\text{ mm} \times (3.10\pm 0.10)\text{ mm}$.
- Moisture sensitivity level (MSL) Level 3.

A two ESP-WROOM-32 MCU's have been chosen with ESP 32 build-in chip in it.

(3) ESP01 WITH 4 Relay - ESP 8266 E01 4 channel Wi-Fi Microcontroller

ESP8266 WIFI 4-Channel Relay Module is a four-channel WIFI relay module carried an ESP8266 WIFI module and mature 8-bit MCU, with a Professional switching power supply circuit. It could control the relay by Android phone APP within the local area network (LAN). It is easy to set.

Reason of use, ESP 8266 have been chosen because it has a variety of specification that achieve the project purpose such as:

- Integrated design.
- DC 5V work power supply.
- Onboard high-quality MCU and ESP8266 WIFI module.
- Additional features: USB Relay Module (Without ESP8266).
- Transmission distance: In the open environment, when a mobile phone is carrying on the WIFI module, the maximum transmission distance is 100 meters.
- Use the "Smart-config" technology to complete the configuration of the account and password of the ESP8266 WIFI module on the mobile APP. The configured account and password will be memorized after power off.
- Optocoupler isolated output, safe and reliable.
- The board contains 220V, 10A/250V AC 10A/30V DC Single original relay, which can continuously absorb 100,000 times, with the protection of diode current and short response time.
- Onboard relay LED indicator, mode option and working statue LED indicator.

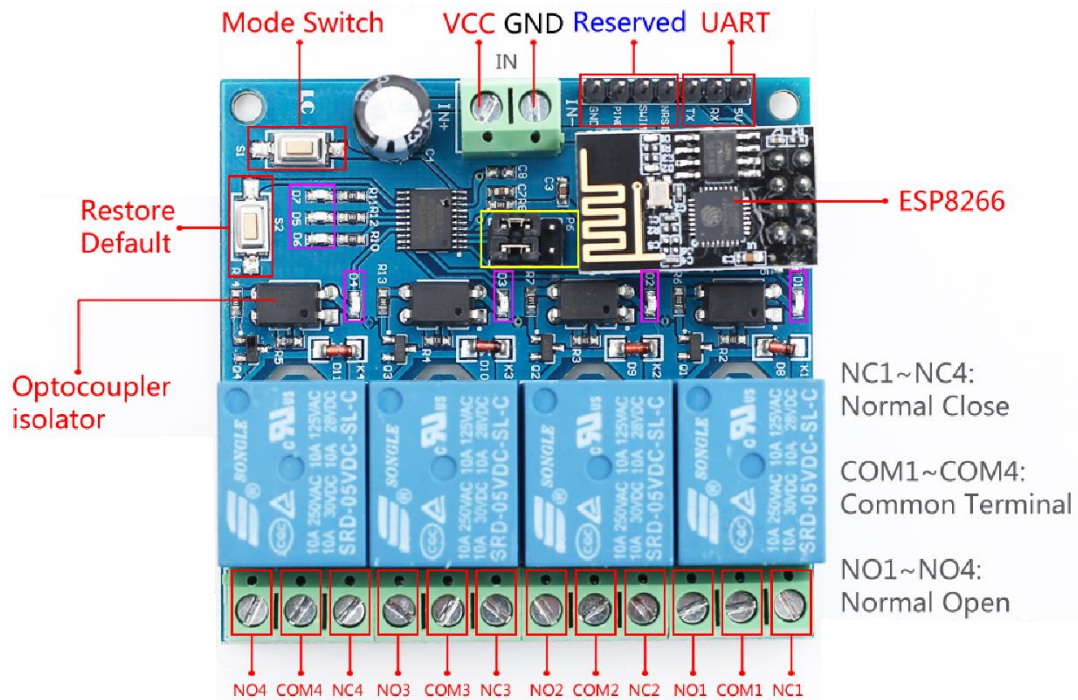


Figure 4.4 ESP01 WITH 4 Relay with Pin Definition and Layout

(4) Database

A database that holds all received parameters such as temperature, humidity level, Soil moisture level, water level, Rain State that's all reserved in schedules stored in large storage devices.

The database has been used is a Cayenne free Cloud by running a private Cayenne server locally.

Reason of use, first it's in free Program use, hold the parameters from the starting time, third is only for a registered user, forth is holding the scheduled data as the user adjust and hold the taggers and alerts data.

(5) Internet Access

According to connectivity, it must have an internet connection on the farm due to make the Transfer data between the Browser and the internet and between the internet and server.

An Internet source is variant from an Internet via Wire Gateway (ADSL, ADSL2+, Optical Fiber) or Internet via Satellite Terminals (DVB, SCPC) or internet via cellular (GPRS, 3G, 4G, 5G) according to the region and the availability of the infrastructure in it the internet source can be selected. If the farm is near a residential area like a city a wire gateway internet is recommended, if the farm is far away from the city but cellular network reaches you the cellular internet is recommended, if the farm is far away area and without infrastructure and cellular network the recommended source Internet via Satellite.

(6) Sensors and measurement devices

It was mentioned in the third chapter

(7) Electrical Motor and liquid valves devices

It was mentioned in the third chapter

(8) Platform and System Application

The main system application would be created and inherited from the Cayenne application.

Cayenne Inc. Provides a platform to enable clients ("Cayenne Clients") to create and manage various mobile and/or web applications ("App" or "Apps") as well as related support and hosting services. Cayenne Clients in turn make the Apps available to their customers ("End Users") for use.

That offers various services (the "Service" or "Services") to the User. Services include our Apps, online services that integrate with the individual items of hardware ("Device") that have been provisioned to access Cayenne Cloud (or "Cloud") to perform various Internet of Things related tasks and functions.

Reason of use, first its free for students' projects, second can connect any hardware over Ethernet, Wi-Fi, or GSM, 2G, 3G, LTE, third its designed for IoT, fourth flexible firmware by C++ that makeup with MCU, fifth cayenne cloud is open-source, sixth cayenne app can be download in any device type and can be open in any browser.

Features and Benefits of Cayenne:

- Connection management: Cayenne Library can connect any hardware over Ethernet, Wi-Fi, or GSM, 2G, 3G, LTE.
- Flexible firmware API: Extensive hardware-cloud-app API. Choose C++, JS, Python, or HTTP.
- Public and private servers: Cayenne Cloud is open-source. It can be run by us, in your cloud environment like Amazon, or privately hosted on your local machine.
- Fast and reliable: Cayenne Server is deployable in minutes. It's real-time and ready to manage billions of requests from your edge devices.
- Designed for IoT: Visualize sensor data, control your equipment remotely, set notifications, rules, and manage multiple devices and more.
- Customizable: Check out the variety of interface elements that you can snap together to build a practical GUI for your product or project.
- Time-effective: Reduce your time to market by fast prototyping and testing your assumptions without hiring a team of designers and engineers.
- Cost-effective: App development is expensive. Our pre-made modules and features reduce your investment when building applications that communicate with the hardware.
- Cayenne supports more than 400 boards already, including support for Arduino, Particle, ARM-MBED, TI-Energia, Micro Python, Node.js, OpenWRT, and many Single Board Computers.

Platforms:

- Arduino.
- Energia.
- Particle.
- ARM-MBED.
- JavaScript (Node.js, Espruino, Browsers).
- Python.
- Lua for NodeMCU.

Connection types:

1. USB (Serial), connected to your laptop or desktop

- Ethernet
- Arduino MKR ETH
- Arduino Ethernet Shield (W5100)
- Arduino Ethernet Shield 2 (W5500)
- SeeedStudio Ethernet Shield V2.0 (W5200)
- ENC28J60-based modules

2. Wi-Fi

- ESP8266 as Wi-Fi modem (running original firmware)
- Arduino Wi-Fi 101 Shield
- Arduino Wi-Fi Shield
- WIZ net WizFi310
- Adafruit CC3000 Wi-Fi Breakout / Shield
- RN-XV WiFly

3. Bluetooth Smart (BLE 4.0)

- HM-10, HC-08
- DFRobot BLE-Link module
- Microduino/cookie BLE
- RedBearLab BLE Mini
- nRF8001-based boards (Adafruit Blue fruit LE.

4. Bluetooth 2.0 Serial Port Profile (SPP) HC-05, HC-06.

5. Cellular (GSM/3G/4G/4G LTE)

- SIM Com SIM800 series (SIM800A, SIM800C, SIM800L, SIM800H, SIM808, SIM868)
- SIM Com SIM900 series (SIM900A, SIM900D, SIM908, SIM968)
- A6/A7
- M590
- BG96
- GPRSbee
- Microduino GSM
- Adafruit FONA (Mini Cellular GSM Breakout), Adafruit FONA 800/808 Shield.

4.4 Connectivity principles

To let the system be simpler to understand, each part has been split by its connection and intermediate that used.

Cayenne Works:

Cayenne was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, and it can store data, visualize it, there are three major components in the platform:

- Cayenne App - allows you to create interfaces for your projects using various provided widgets.
- Cayenne Server - responsible for all the communications between the smartphone and hardware.
- Cayenne Libraries - for all the popular hardware platforms - enable communication with the server and process all the incoming and outgoing commands.
- Now imagine: every time you press a button in the Cayenne app, the message travels to space the Cayenne Cloud, where it magically finds its way to your hardware. It works the same in the opposite direction and everything happens in a Cayenne of an eye.

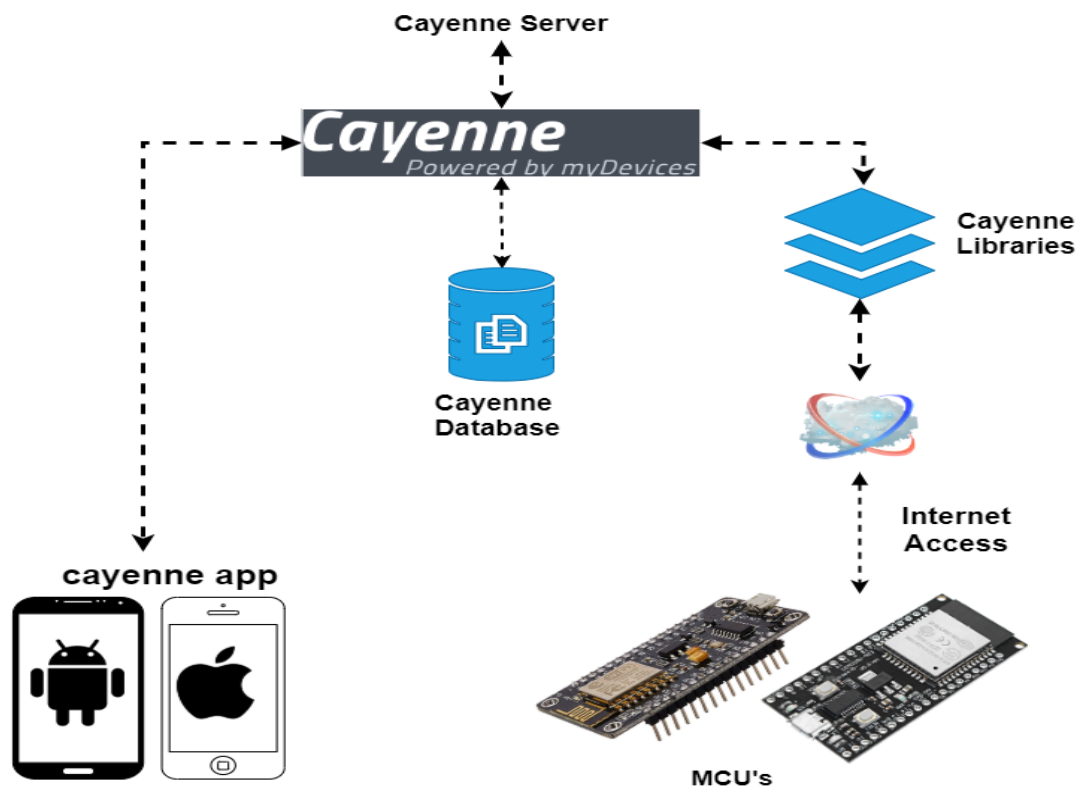


Figure 4.5 Cayenne Works Layout

ESP WITH 4 Relay Work:

The MCU is connected to the internet via Wi-Fi, it controls 4 relays and 4 ports of pins that used for sensors feedback in this

- Relay for Pump Motor to turn it on or off.
- Two Relay's for electric Valves to Control the flow of water.
- Relay for the valve that fertilizer solutes with water.
- One pin of GPIO for the level sensor that gives the feedback of the water level in the tank.
- One pin of GPIO for Flow sensor that gives feedback of water flow in pipelines.
- Two Connectors for Electric power Feed.

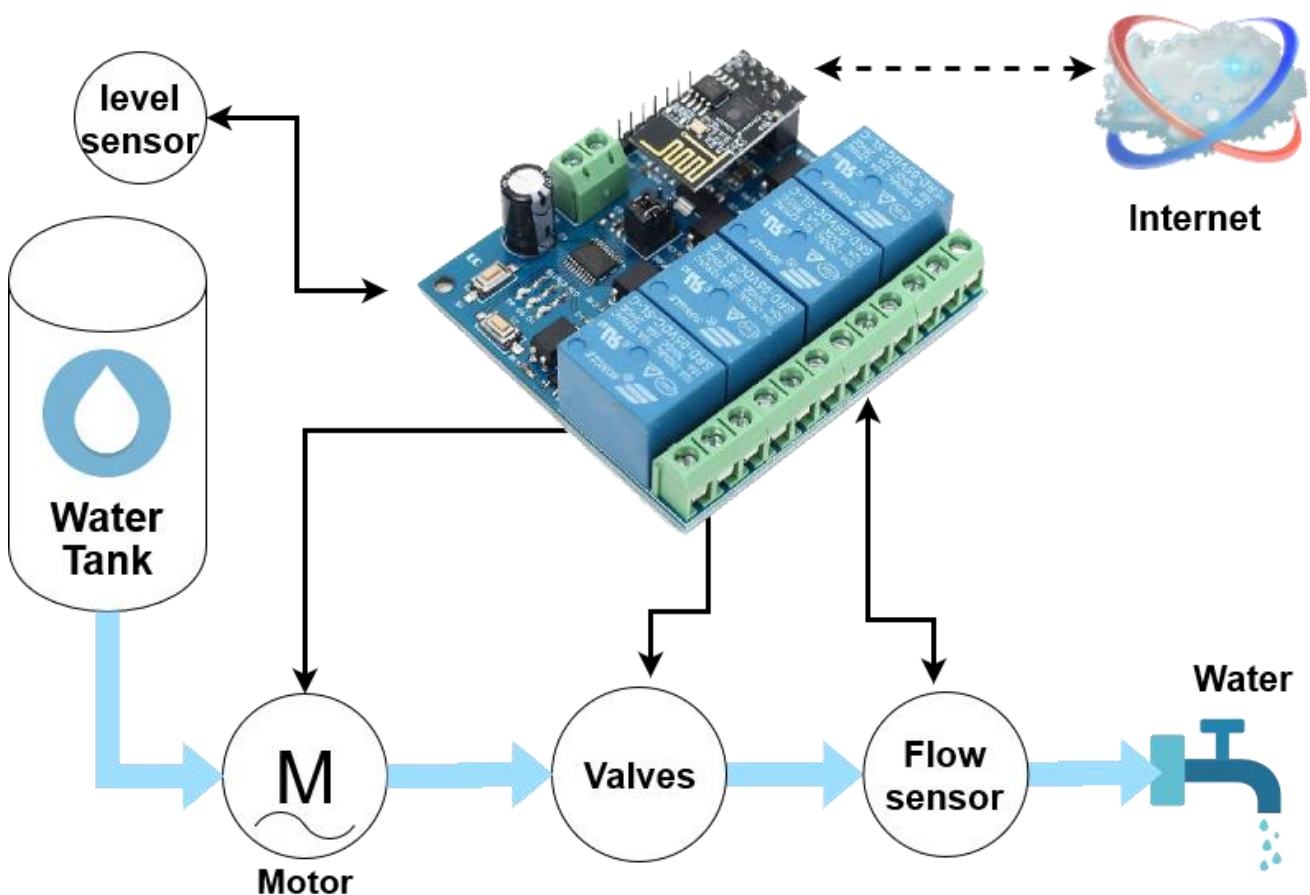


Figure 4.6 ESP WITH 4 Relay Work layout

ESP WROOT 32 Work:

The MCU is connected to the internet via Wi-Fi, it controls 38 ports of pins that is GPIO, ADC, and TOCH, it's been used for sensors feedback and controls sensors parameters and send it to the database by this figure:

GPIO for Temperature sensor

GPIO for the humidity sensor

GPIO for PH sensor

GPIO for Rain Sensor

GPIO for the light sensor

GPIO for the Soil moisture sensor

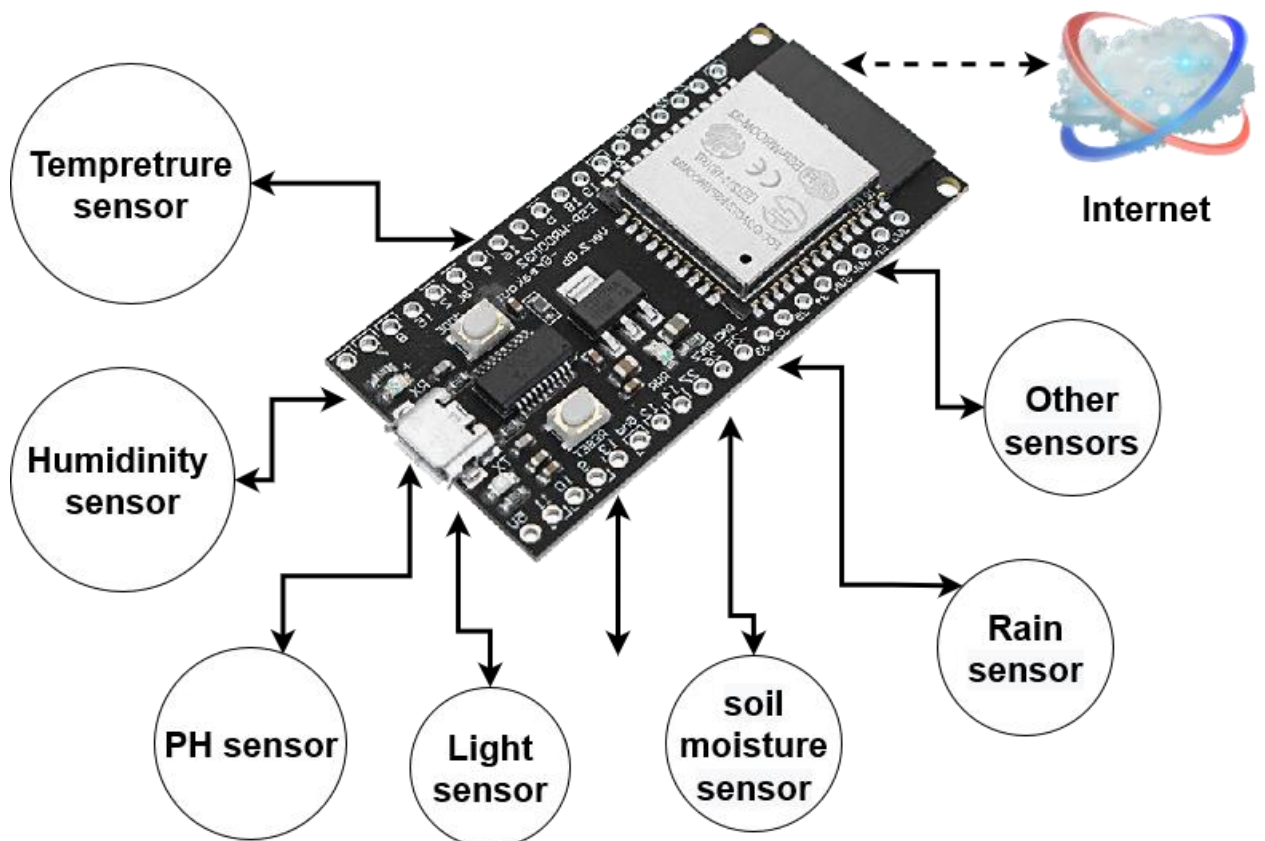


Figure 4.7 ESP WROOT 32 Work layout

4.5 The ALGORITHM SYSTEM

Starting the algorithm with reading order to all sensors parameter that connected to the MCU and storing it in the memory, while at the same time a parallel process start to gather the comparison parameter from the database.

Next Process comes the comparing operation between parameters that came from the database, collected from sensors, and modified from the user.

After the comparison test, the action must take in the priority of :

first, to install the user input parameters in the database.

second, if there it's a difference between the user parameters and what parameters read from sensors the actions will start to apply to run the specific output that will make the parameter the correct according to the right.



a time of one minute will take as a delay to make the changes in the parameters by applying the actions.

another comparing operation starts to measure the values of sensors parameters are the same as in the database or not.

If yes it's the same well make the next read sensors parameters after every five mints until detects a difference in the values of parameters. if no, the system will go immediately to comperre the database parameters again and reading sensors parameters.

The Algorithmic of all MCU is the same Protocol steps but deferent sensors and deferent Outputs.

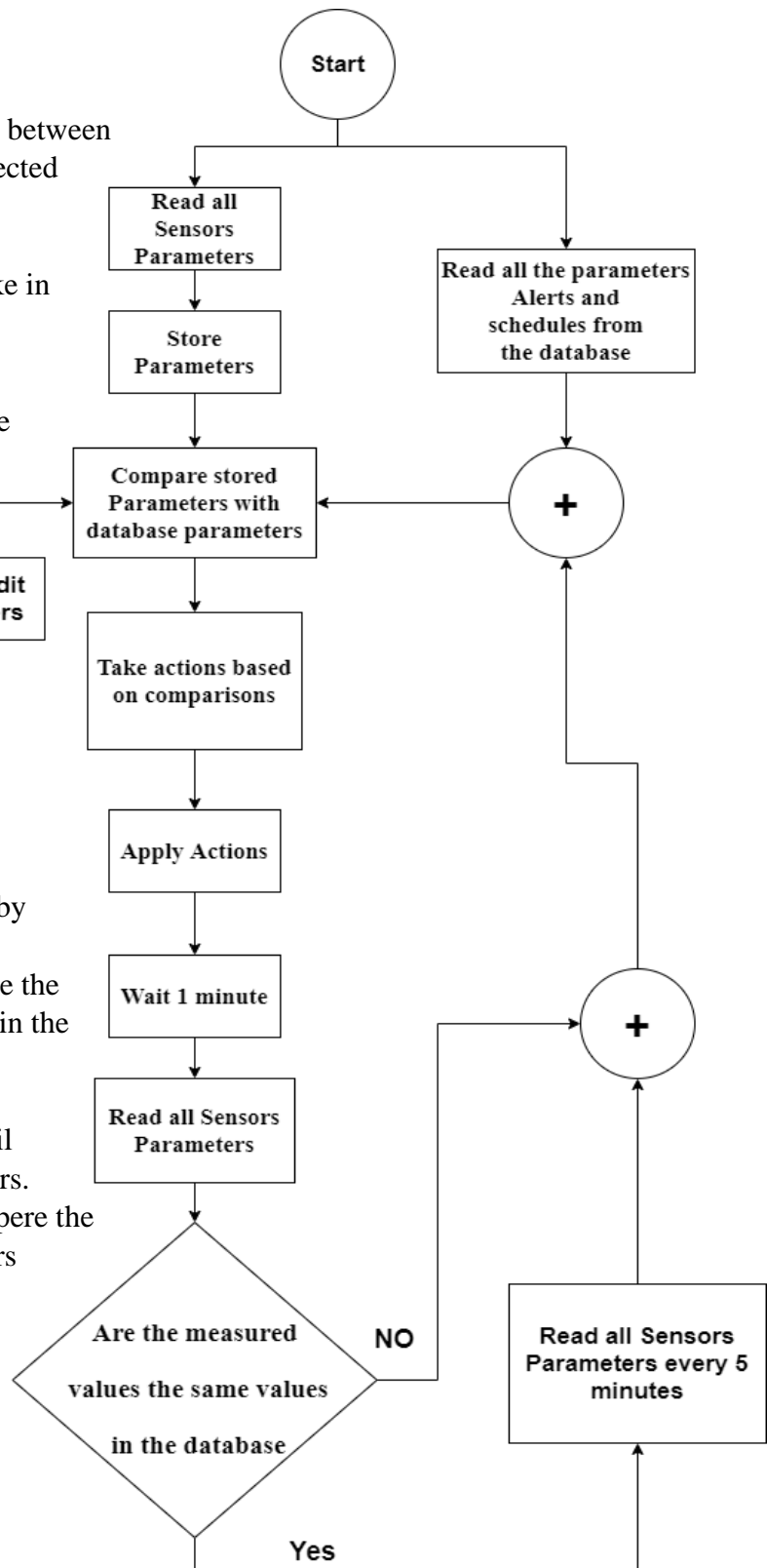


Figure 4.8 ALGORATHIM SYSTEM

5 Chapter Five Results

5.1 Hardware results

5.2 Software results

1 Application Results

2 Web Browser Results

3 Scheduling Results

4 Triggers and Alerts Results

5.3 How to Use the Project

5.4 Prototype Results

5.1 Hardware results

Electric devices setups

1st Controller is WeMos D1 Mini that monitors the water level in tanks and the flow of water in pipelines. Figure 5.1.

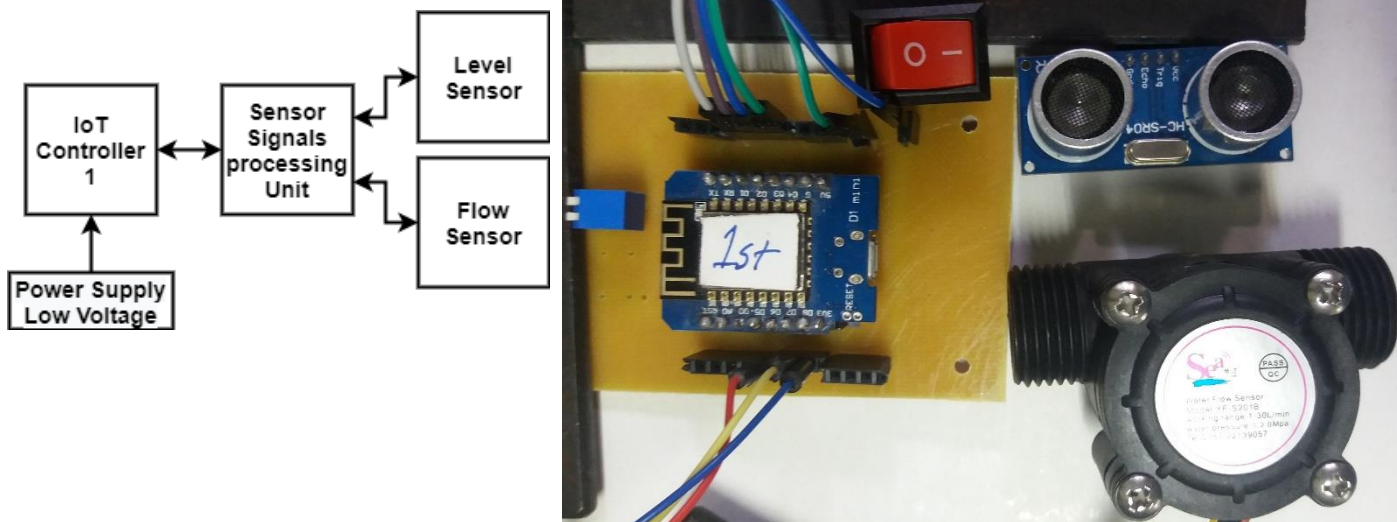


Figure 5.1 - 1st Controller, Ultrasonic Level Sensor, and Water flow sensor.

2nd Controller is the ESP32 WROOM module that monitors the Rain state, Air humidity and temperature, and the light intensity. Figure 5.2.

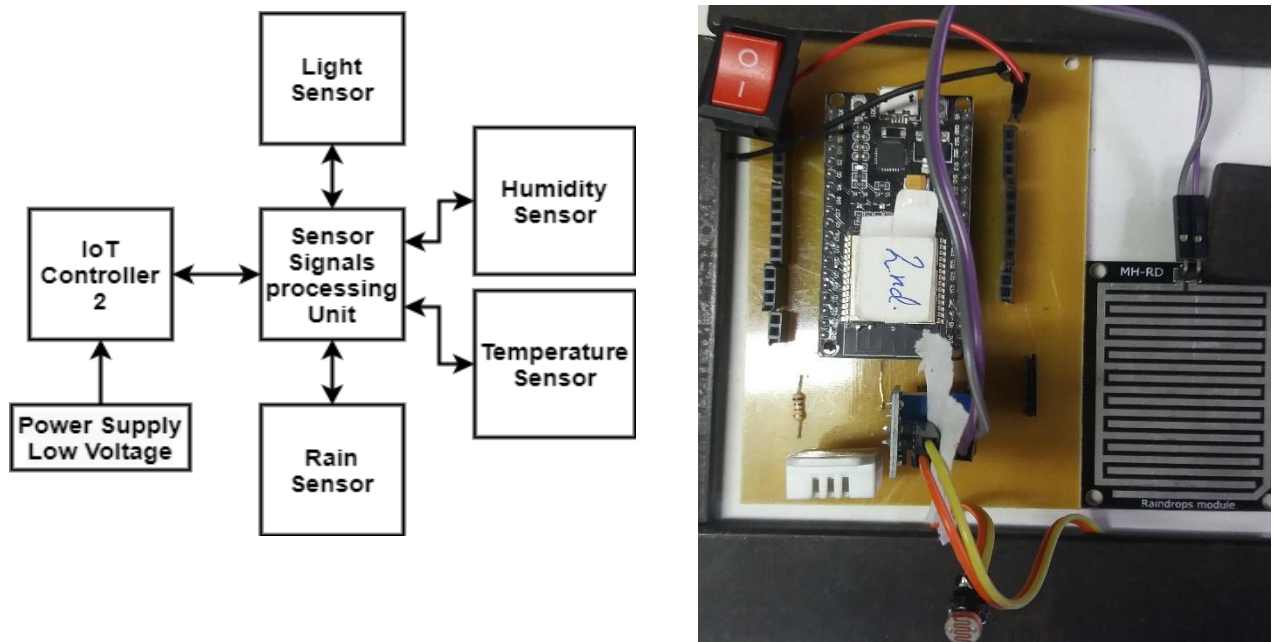


Figure 5.2 - 2nd Controller, Rain sensor, Light sensor, and DHT 22

3rd Controller is ESP01 with 4 relays that control the Lights, Fan motors, and Shutter motor ON/OFF. Figure 5.3.

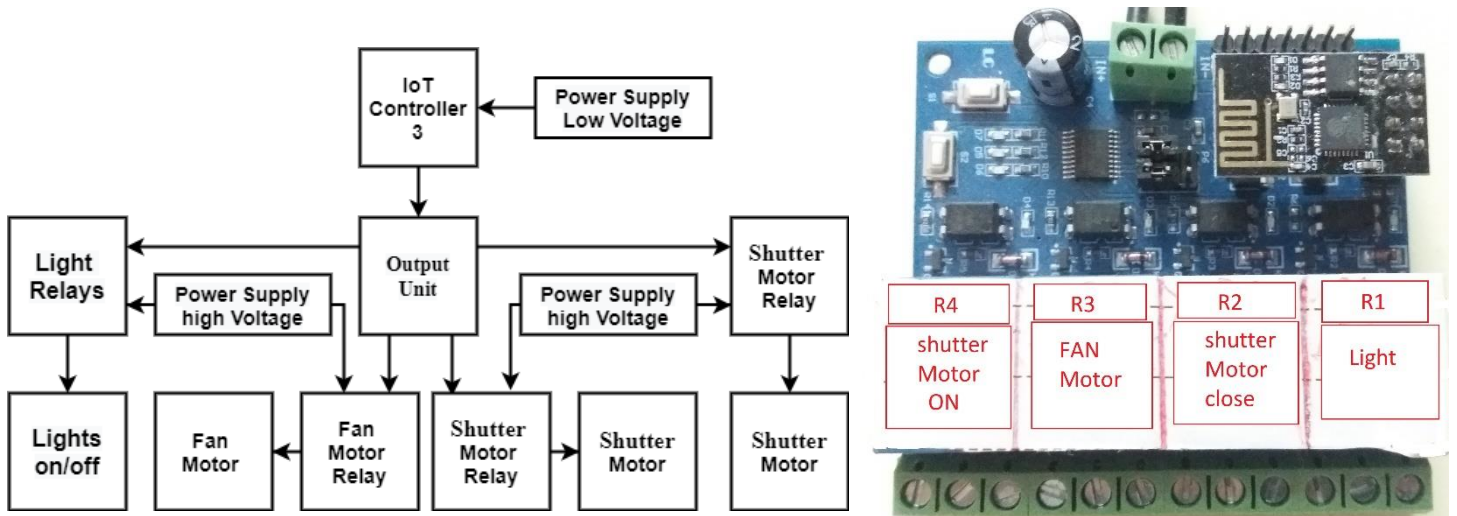


Figure 5.3 - 3rd Controller, and 4 Relays

4th Controller is WeMos D1 Mini that monitors Air humidity and temperature and the Soil Moisture Sensor. Figure 5.4.

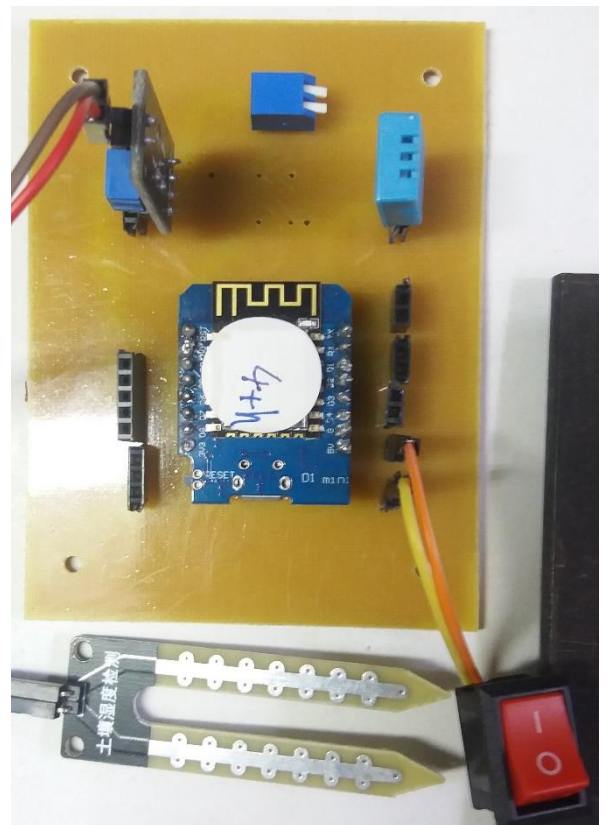
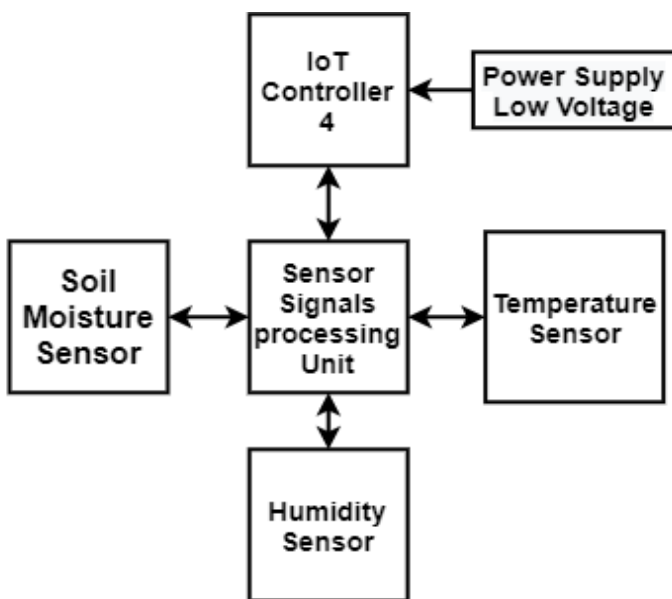


Figure 5.4 - 4th Controller, DHT 11, and Soil Moisture Sensor.

The 5th Controller is ESP01 with 4 relays that control the Water Dump motor, Water Valve, and Compost Valve. Figure 5.5.

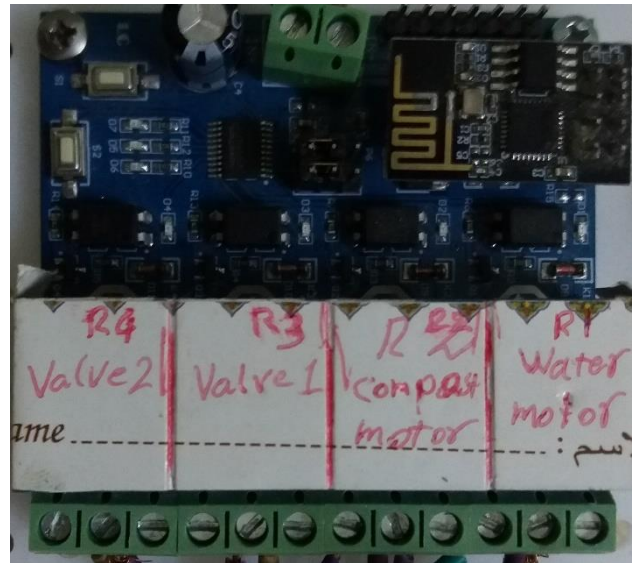
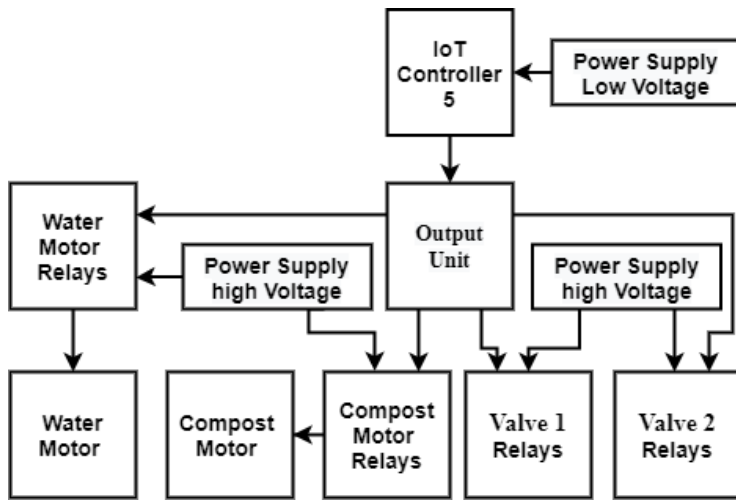


Figure 5.5 - 5th Controller, and 4 Relays

6th Controller is the ESP32 WROOM module that monitors the Air humidity and temperature, the Soil Moisture sensor, Soil pH sensor, and light intensity. Figure 5.6.

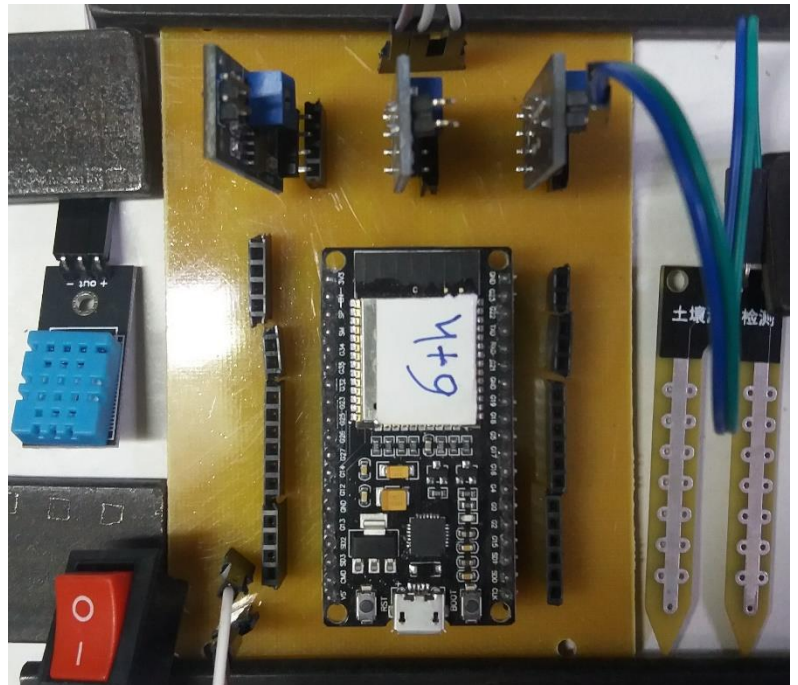
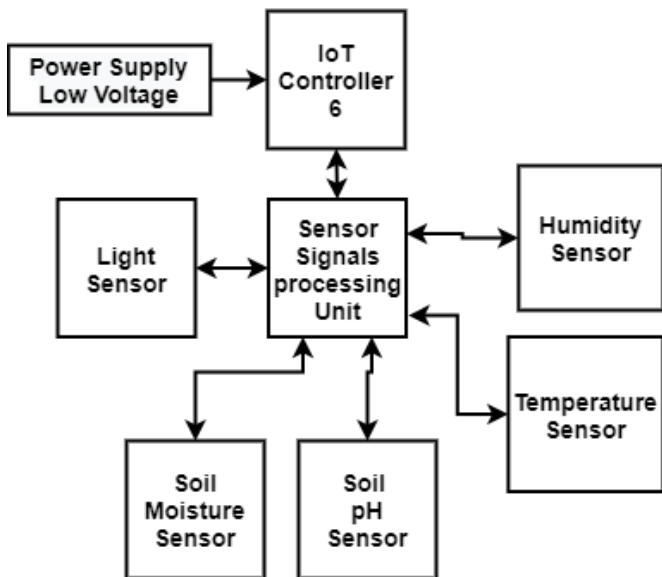


Figure 5.6 - 6th Controller, DHT 11, Soil Moisture Sensor, and ADC Modules for Soil pH, Soil Moisture, Lights.

7th Extension Controller is ESP01 with 4 relays that are a expand made for future use to control ON/OFF devices. Figure 5.7.

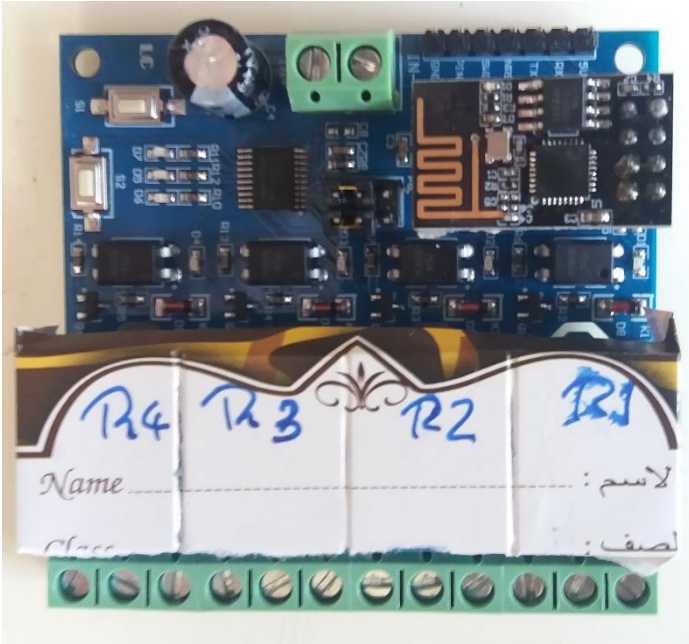
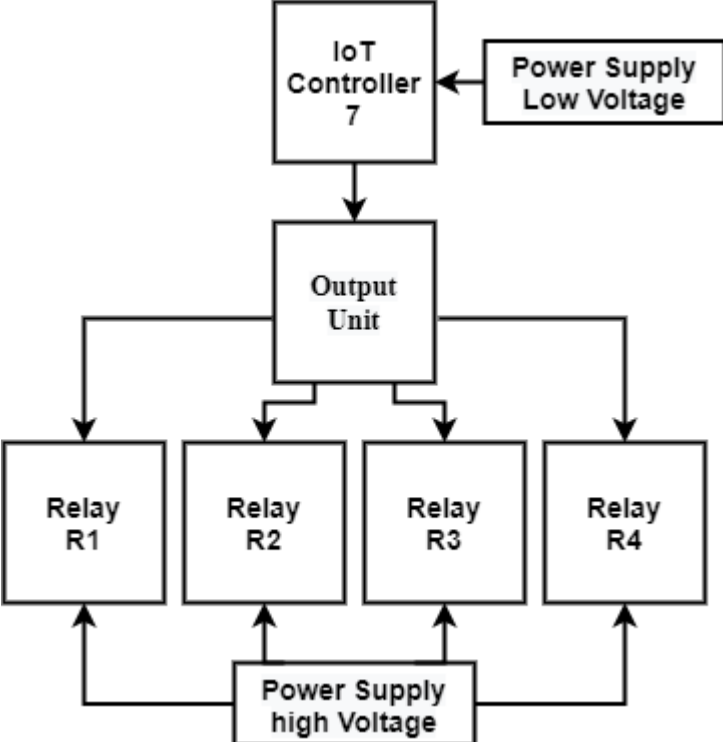


Figure 5.7 - 7th Extension Controller and 4 Relays

5.2 Software results

Cayenne is the Main platform that runs in all the systems together in any interface device synchronously.

It supports any browser application, Android system, and IOS Apple mobile smartphone system.

The interface scale is different from application to another and from device to another but all do the main purpose.

(1) Application Results

The Android application icon shows in figure 5.8.

When starts the program a Devices window pup out figure 5.9.

when press in the menu icon ‘≡’ a menu par contains a Projects, Devices, and Community figure 5.10.

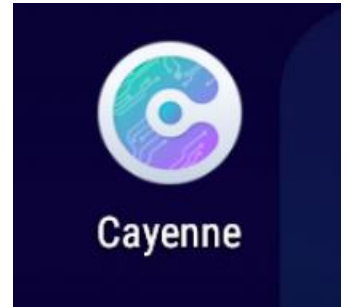


Figure 5.8 Cayenne Icon

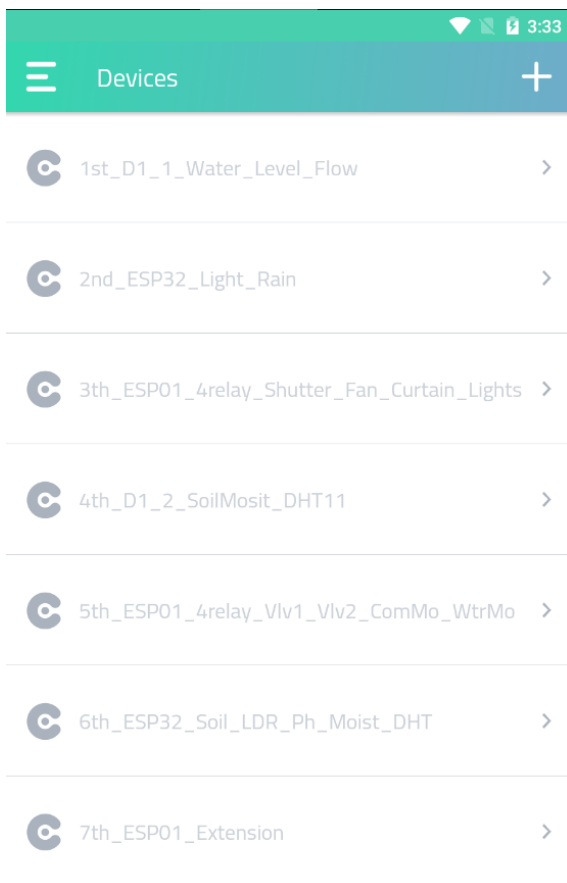


Figure 5.9 Devices Window

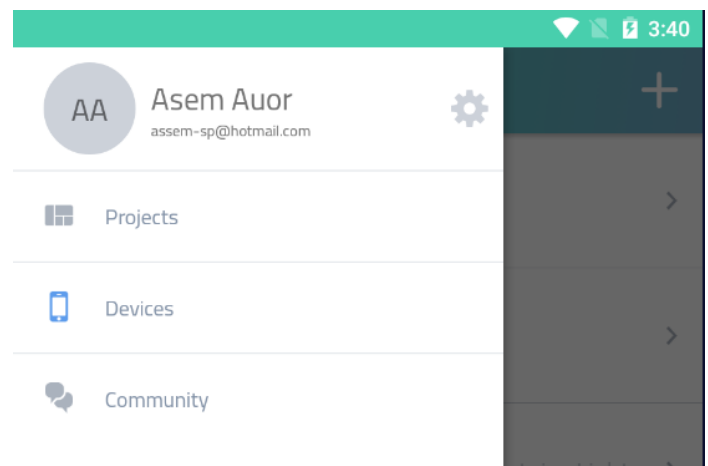


Figure 5.10 Menu Window

The Android application system figure 5.11 has three taps.

- 1st tap Monitor the probes
- 2nd tap Up Times
- 3rd tap Relays

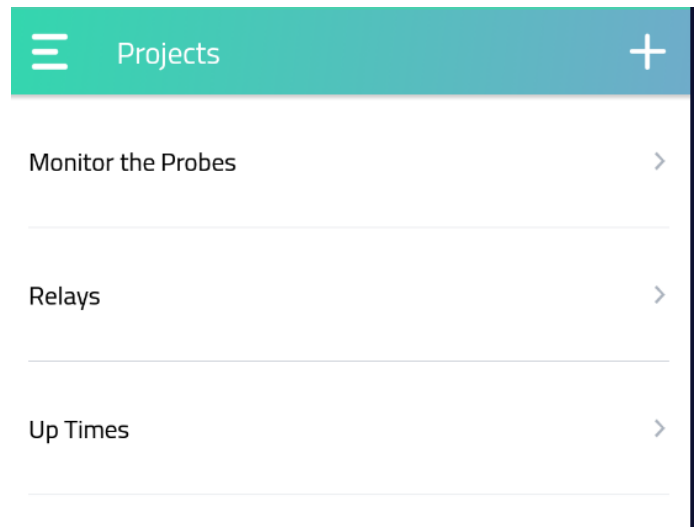


Figure 5.9 Project Window

First tap Monitor the probes that contain all the sensor's values figure from all devices. Figure 5.12

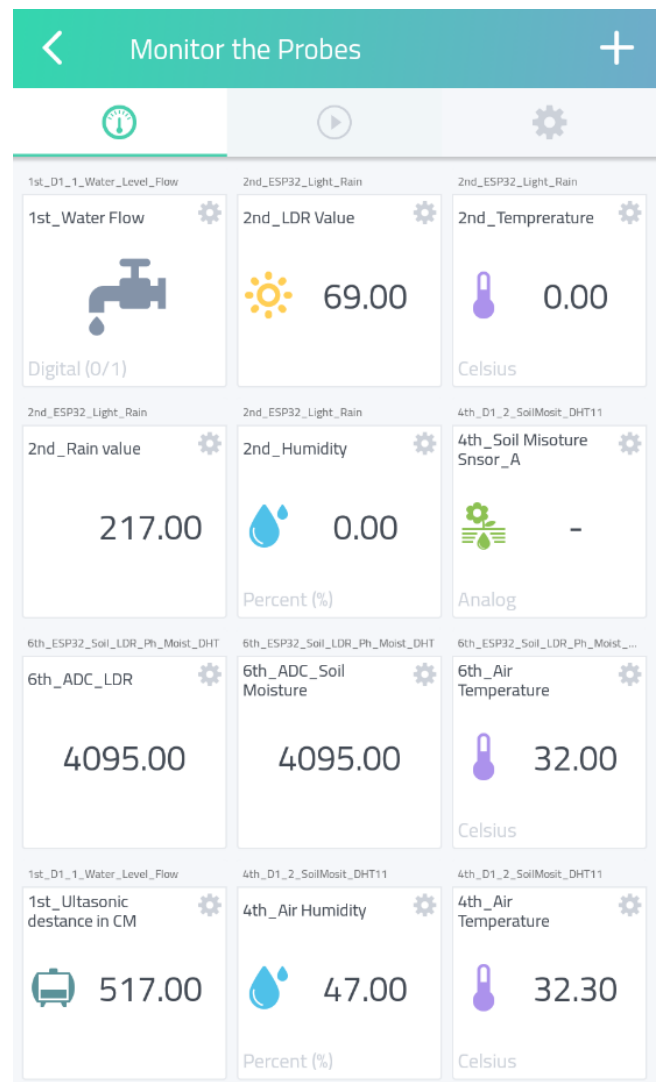


Figure 5.10 Monitor the probes Window

The second tap is Relays

Figure 5.13 shows the relay state if ON or OFF and the user can select the button to ON or OFF.

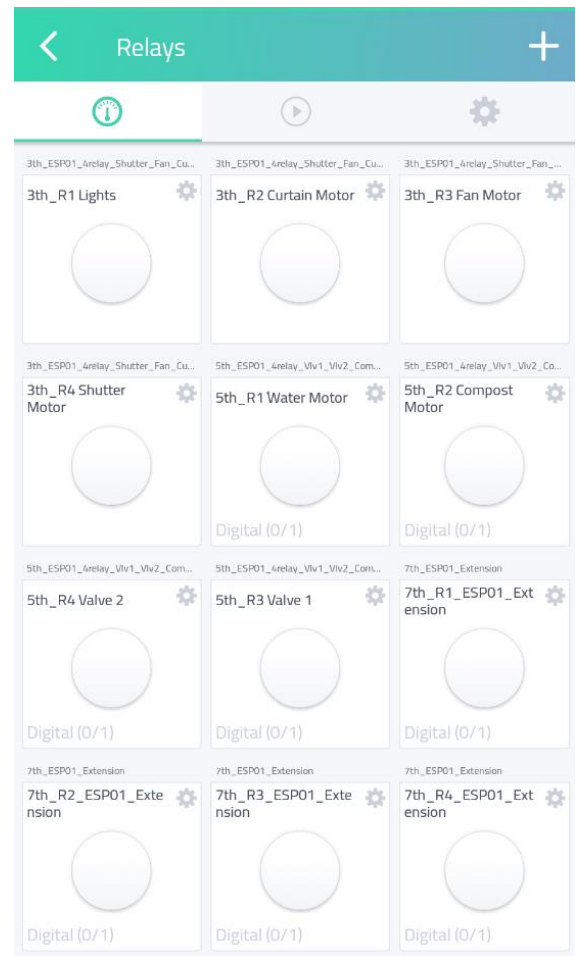


Figure 5.11 Relay Window

The third tap is Up Times

Figure 5.14 shows the current uptime in milliseconds for each device

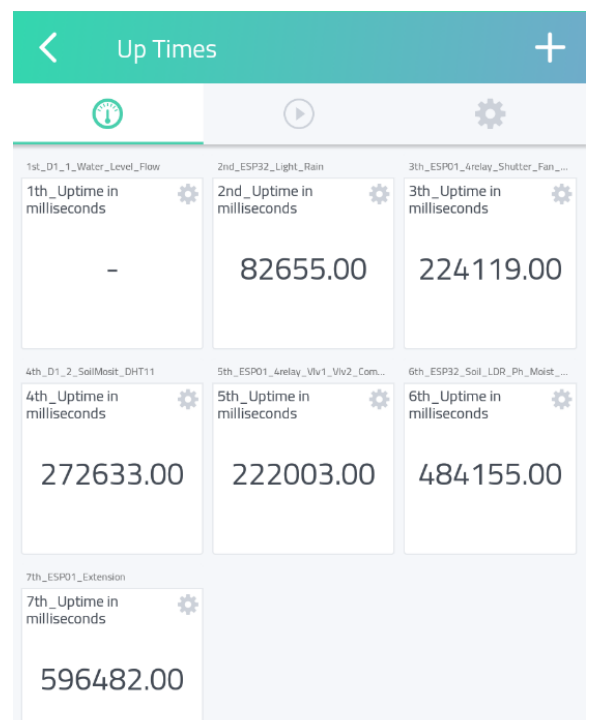


Figure 5.12 Up Times Window

(2) Web Browser Results

The Web site is: <https://cayenne.mydevices.com/cayenne/dashboard> then Enter the username and password then start the dashboard interface.

The interface browser application system has three taps as in figure 5.15
1st tap Monitor the probes
2nd tap Up Times
3rd tap Relays

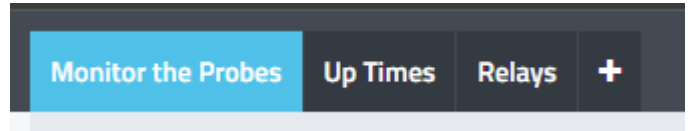


Figure 5.13 Browser three taps.

First tap Monitor the probes that contain all the sensor's values. Figure 5.16.

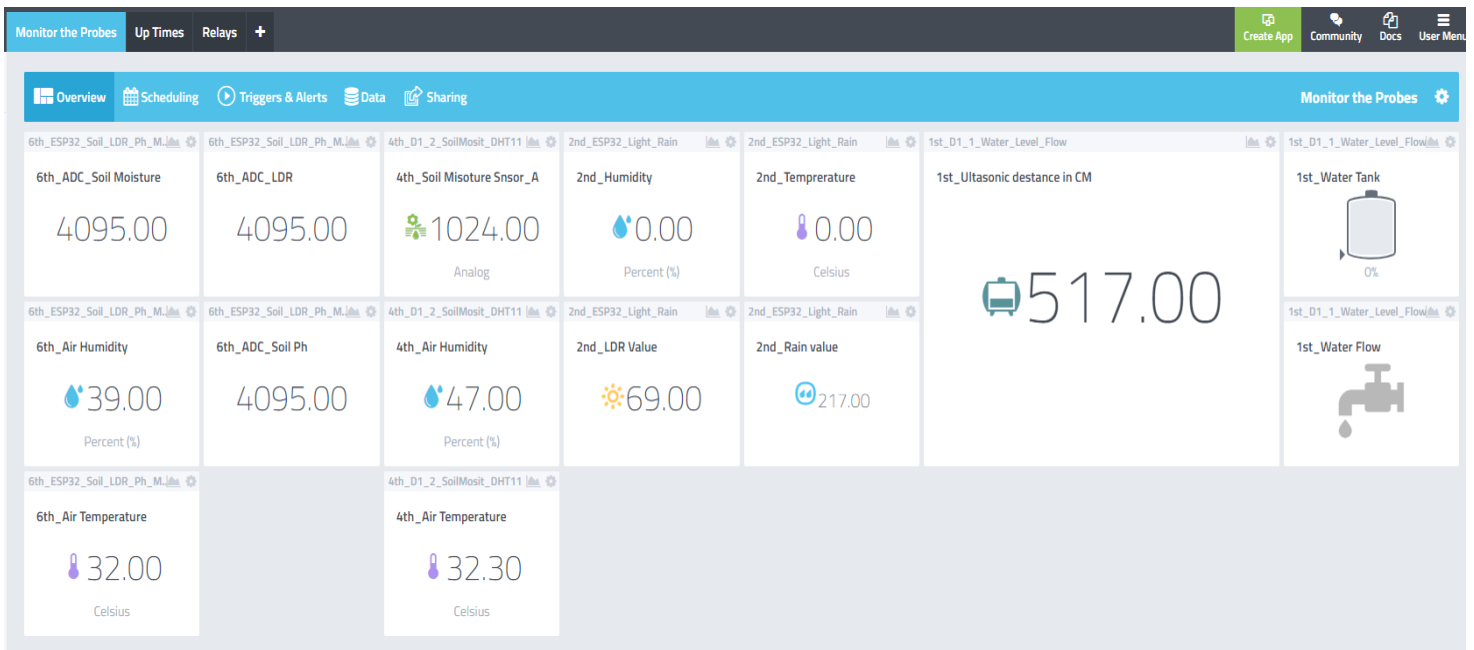


Figure 5.14 Monitor the probes Window tap.

Second, tap the current uptime in milliseconds for each device. Figure 5.17.

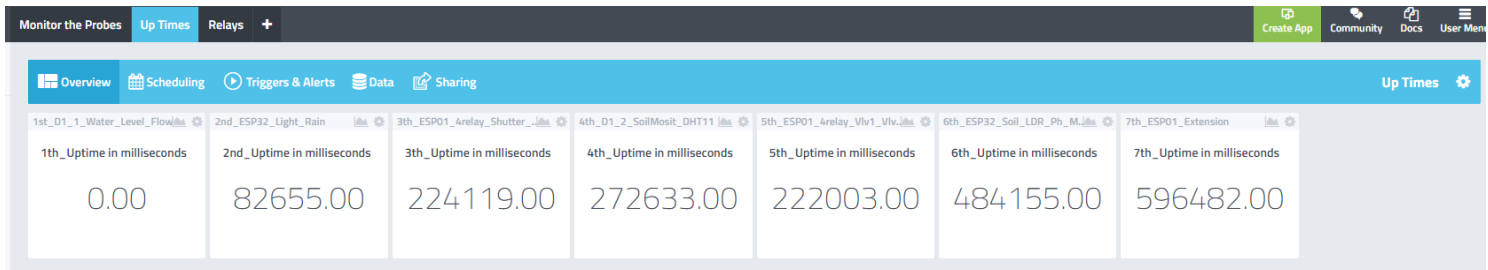


Figure 5.15 Uptime Window tap.

The third tap is Relays shows the relay state if ON or OFF and the user can select the button to ON or OFF. Figure 5.18.

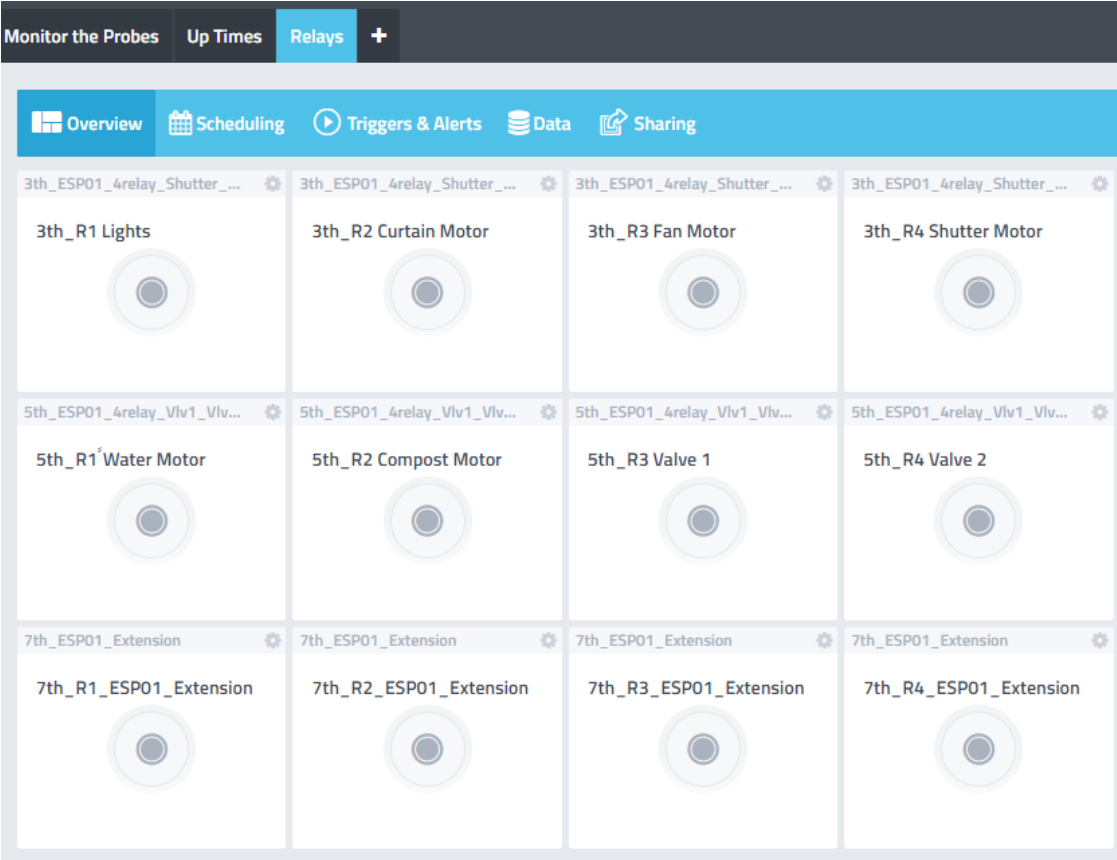


Figure 5.16 Relay Window tap.

The Menu Bar shows the devices list figure and each connected widget. Figure 5.19.

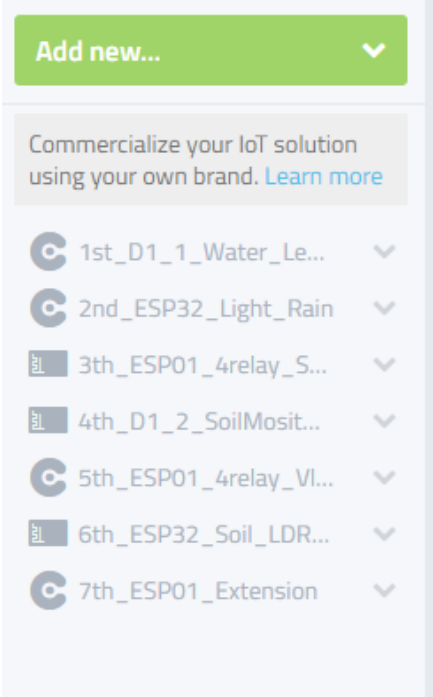


Figure 5.17 The Menu Bar

(3) Scheduling Results

The Cayenne application allows creating scheduled events for sensors and actuators connected to any controller. A scheduled event can have one or more actions added to it.

Events like Start / Stop watering the plants every time in the morning and night.

To show an Event, press on the scheduling button. Figure 5.20.

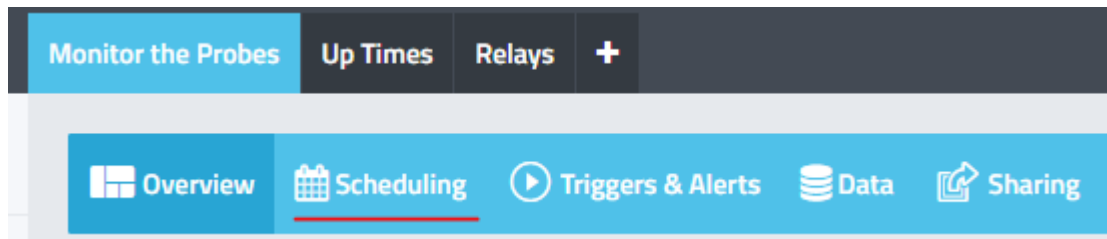


Figure 5.18 the scheduling button

An Event List shows up with all the events that are made, and it available to deactivate or check or edit. Figure 5.21.

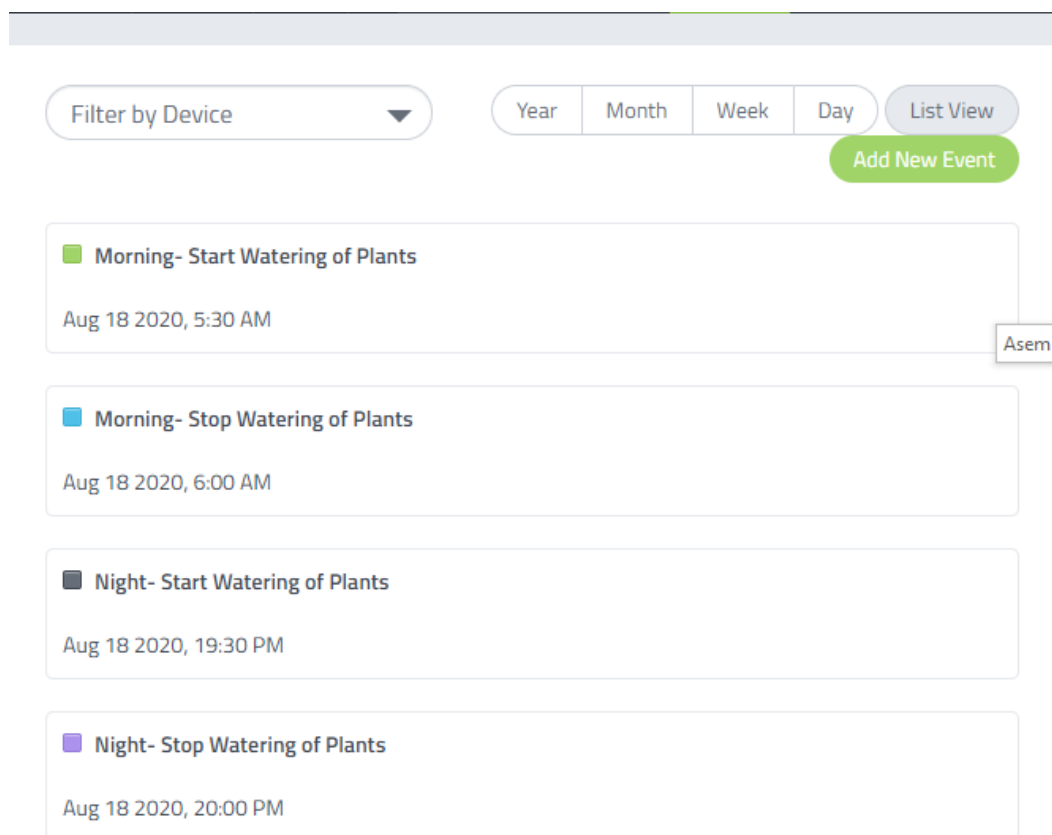


Figure 5.19 Events List

The event contains

- Name of the event
- Date and Time fields
- Repeat the scheduled event to occur
- Setup notification field
- Action field

The event figure 5.22 shows the Start Watering the plants in the morning, puts a time to run a water pump, and opens the water valve automatically.

The Alerts where listed is:

- Morning- Start Watering of Plants (05:30)
- Morning- Stop Watering of Plants (06:00)
- Night- Start Watering of Plants (19:30)
- Night- Stop Watering of Plants (20:00)

Figure 5.20 the Start Watering Edit Event Window.

The view of the scheduling system with the events in the form of days. Figure 5.23.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22

Figure 5.21 daily schedule system in monthly view

(4) Triggers and Alerts Results

The Cayenne application allows creating triggered actions on and between your sensors and actuators based upon the state devices. Simply put if a trigger event happens, then a resulting action happens, as the IF statements in programming language algorithms,

To show triggers and alerts, press on the Trigger and Alerts button. Figure 5.24.

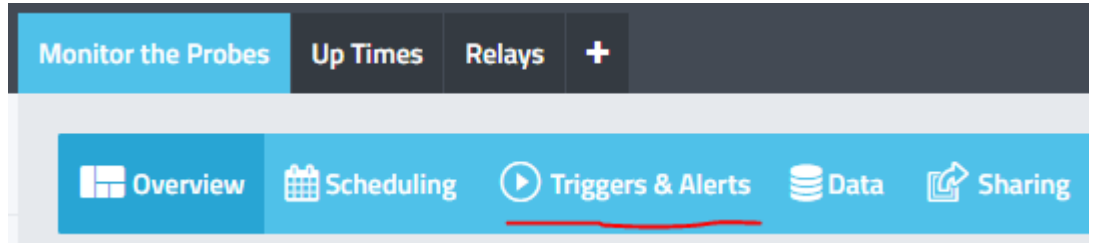


Figure 5.22 The Trigger and Alerts button

A Triggers List shows up with all the events that are made, and it available to deactivate or check or edit. Figures 5.25, 5.26.

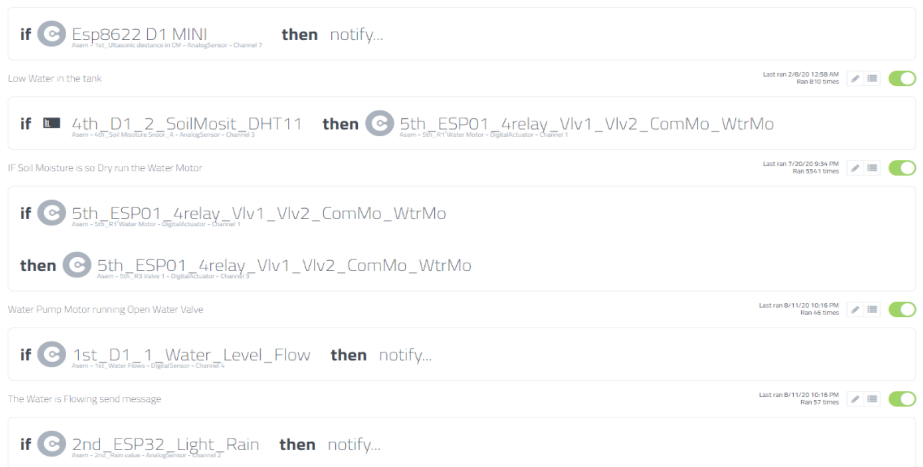


Figure 5.23 A Triggers List

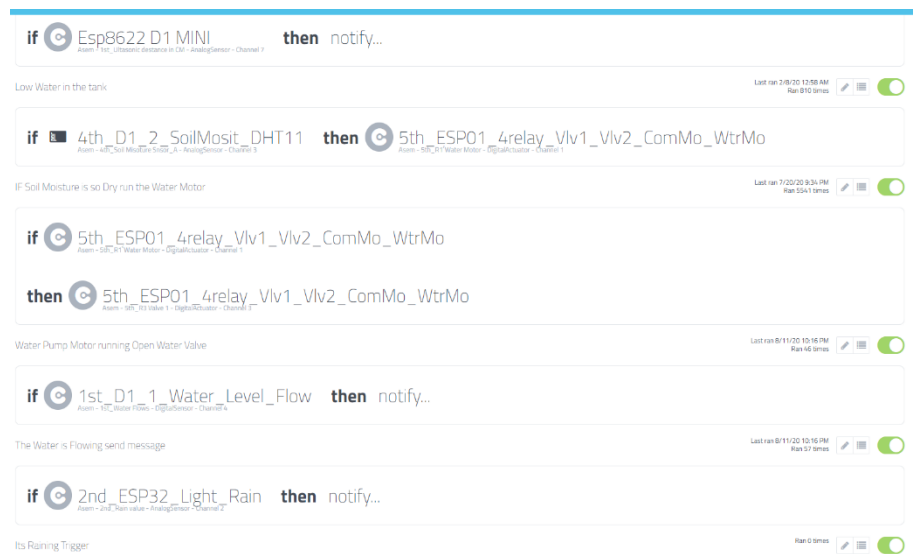


Figure 5.24 A Triggers List Cont.

Application the Triggers are listed in a Play icon '▶' in any project tab figure 5.27.

The Triggers where listed is:

- IF Low Water in the tank Send a text message.
- IF Soil Moisture is Dry then run the Water Motor for a 5 mins.
- IF Water Pump Motor running Open Water Valve.
- IF The Water is Flowing send text message.
- IF It's Raining Send Text message.
- IF Sunset then Turn ON the Lights.
- IF high Temp Then then OPEN the Shutter.
- IF Humidity is above 70% then Open Shutter.
- IF the soil pH is below 7 then Run the Compost motor to put Compost.
- IF Compost motor run then Run water pump.

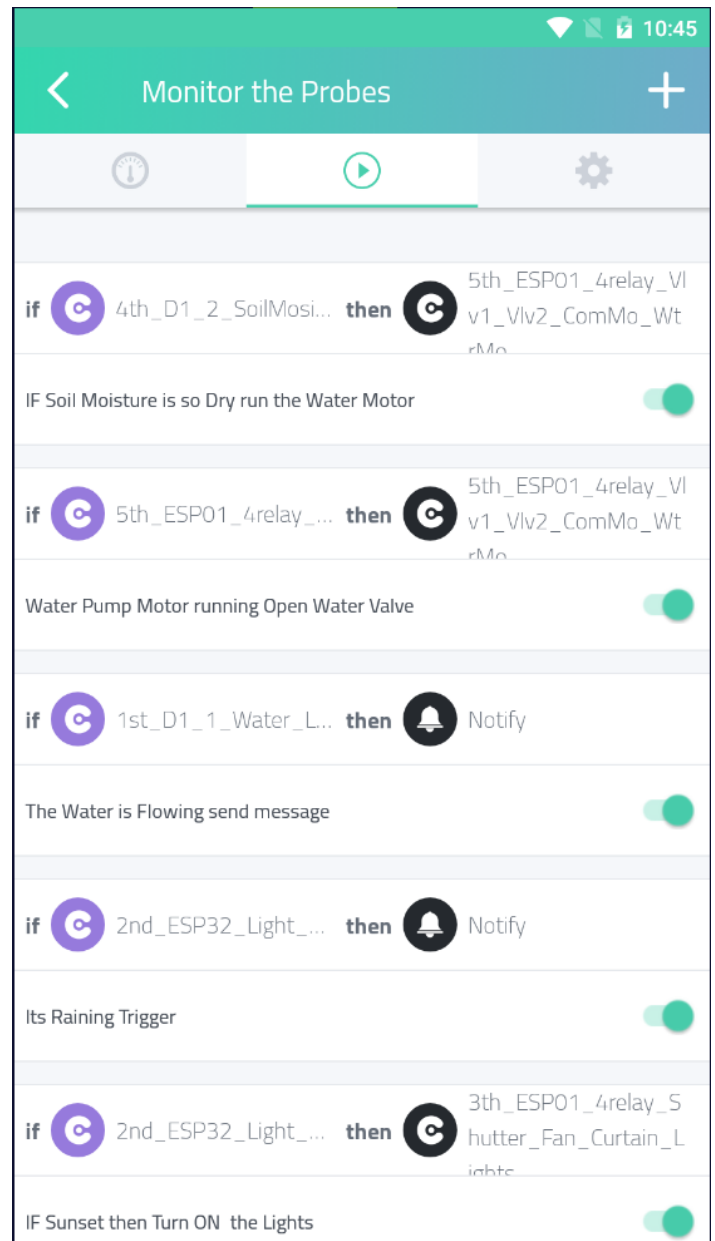


Figure 5.25 list of Triggers in Android Application.

5.3 How to use the Project

First to get started you need to log in or create Cayenne account on the sign-up page figure 5.26, enter your Name, Email and create a Password

<https://accounts.mydevices.com/auth/realms/cayenne/protocol/openid-connect/registrations>

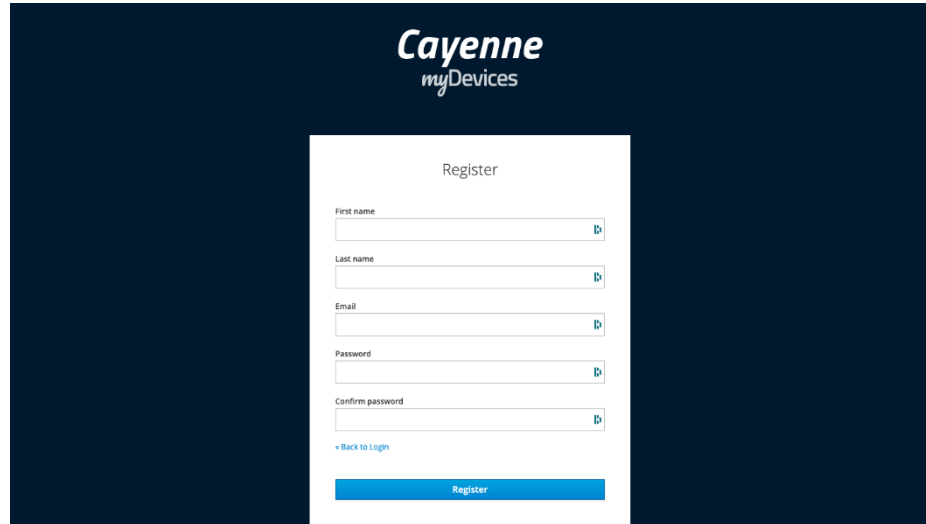


Figure 5.26 the sign-up page

Second must insert the name of the Project

Third choose devices that Cayenne supports like Raspberry Pi, Arduino and LoRa devices. Select the device you would like to get started with in your IoT project.

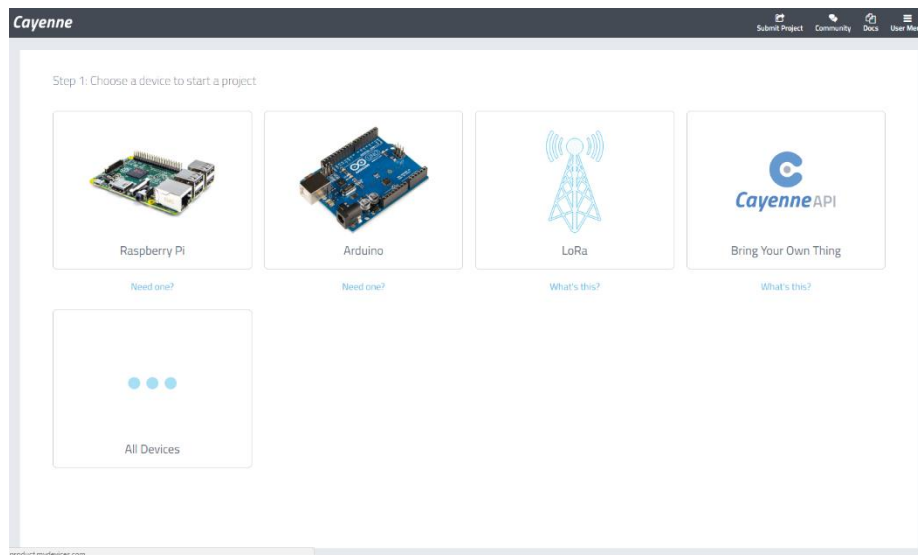


Figure 5.27 choose Device panel

Forth if we select an Arduino IDE device then must use the Cayenne Arduino Library.

The Cayenne MQTT Arduino Library is a collection of code, known as sketch files, that makes it easy for you to connect and send data to and from sensors, actuators and devices connected to Arduino boards. Cayenne sketch files can be combined with other sketch files for

your IoT projects. In this section we will walk you through installing and configuring the Arduino IDE to use the library.

Fifth Add Cayenne Library to Arduino IDE

The Cayenne MQTT Arduino Library is available directly from the Arduino IDE Libraries list. To install the library, select Sketch > Include library > Manage Libraries figure 5.28. The Library Manager dialog will appear figure 5.29. From here, search for the Cayenne MQTT library and install it.

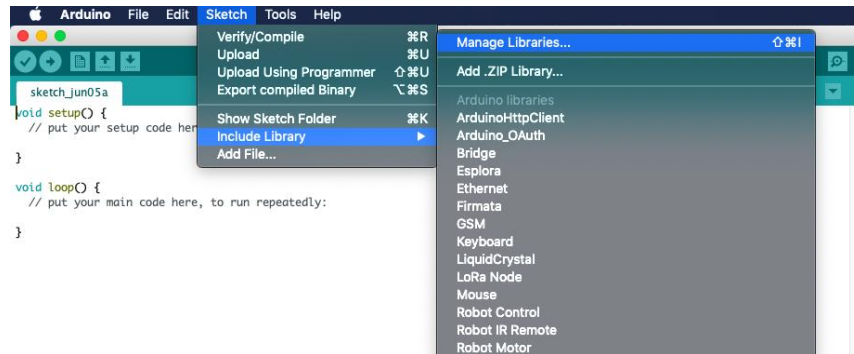


Figure 5.28 Manage Libraries Panel



Figure 5.29 The Library Manager dialog

The Cayenne MQTT Arduino library has now been expanded in the libraries folder in your Arduino sketches directory. You can verify this by going to the Sketch > Include Library menu where you should now see the Cayenne MQTT library at the bottom of the drop-down menu under Contributed Libraries. The Cayenne MQTT Arduino library is now ready to be used in your project.

Sixth Configure Arduino IDE

In order to successfully program your Arduino board, you will need to verify that the appropriate Board and Port are selected in the Arduino IDE.

First, verify that the correct Board is selected in the Tools > Board menu Figure 5.30. Be sure to select the board type that you will be programming.

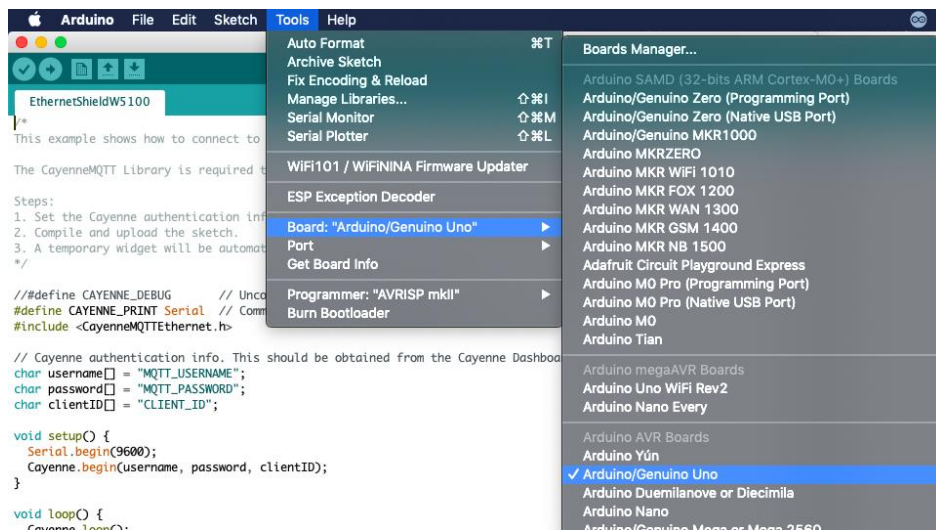


Figure 5.30 Board menu

Then, verify that you have the correct Port selected for communicating with your Arduino. Pick the correct port based upon how you are connecting your Arduino or ESP to your PC/Mac. Figure 5.31.

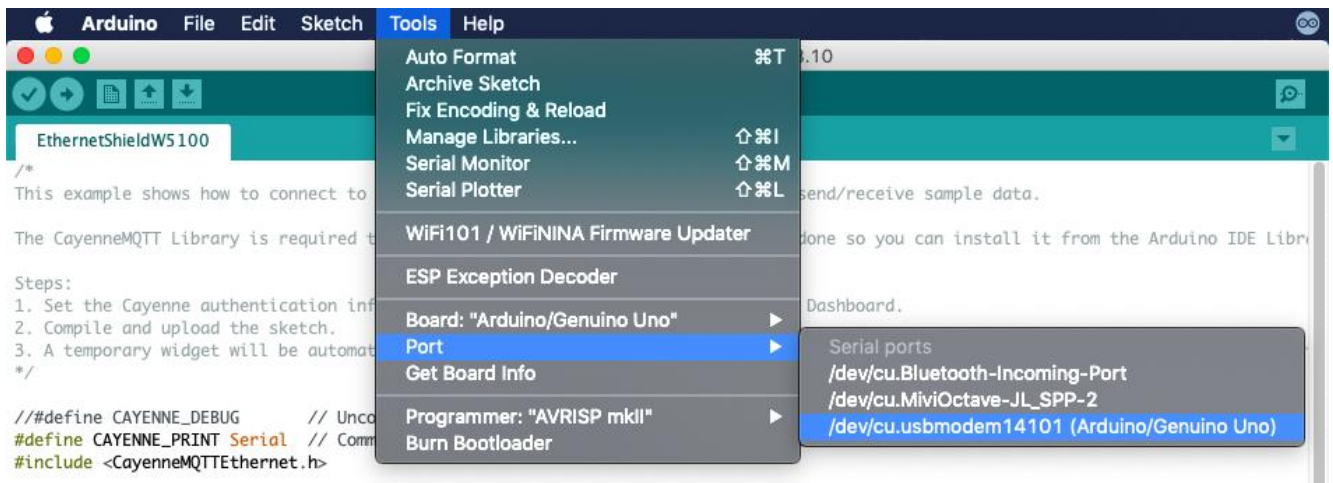


Figure 5.31 Port menu

Seventh Connect your Arduino or ESP

After setting up your PC/Mac computer with the Arduino IDE and the Cayenne Library, you are ready to install Cayenne onto your device. Continue to Step 3 of the Arduino installation, where you will connect your board with Cayenne.

On this screen, select the Arduino board that you are using from the list of supported boards figure 5.32. As you select your Arduino board, a list of connections appears below the board name. Select the connection type that you are using.

Click on the Sketch button next to the connection you will be using and a popup will appear with the sketch file you will need when flashing your Arduino device. The sketch file will contain everything you need to connect your device to Cayenne.

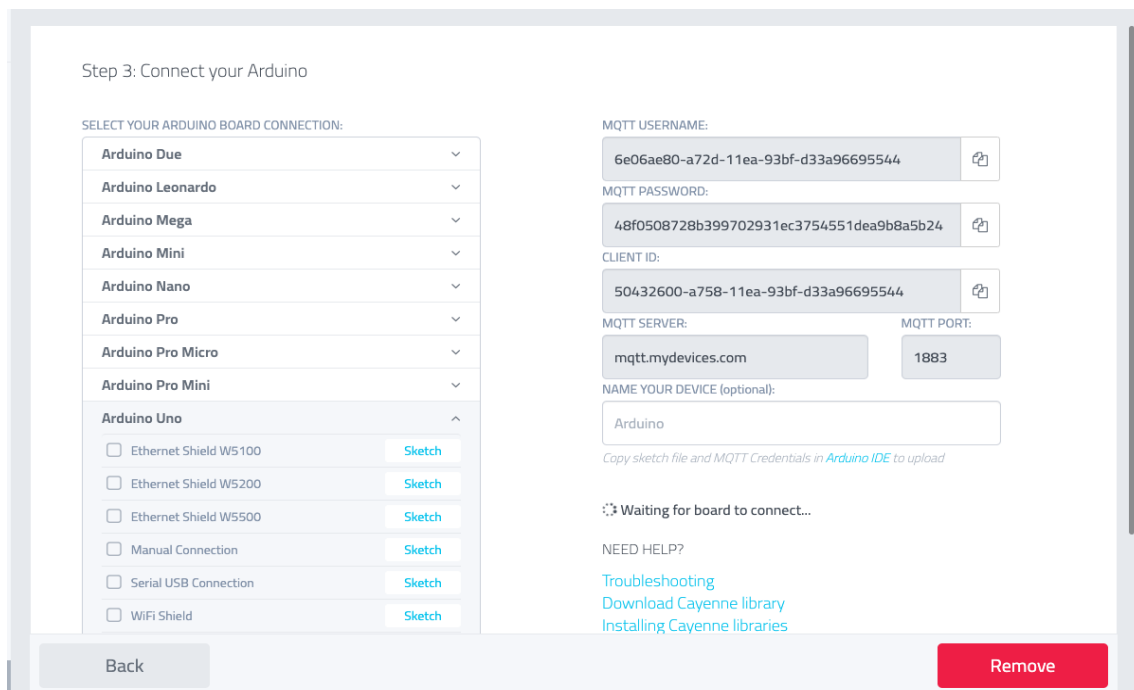


Figure 5.32 the list of supported boards

Verify your MQTT credentials

MQTT credentials are unique identifier that connects your Arduino board to the Cayenne Cloud and enables interactions to and from Cayenne and your hardware. Each cayenne account has unique MQTT Username and password while each device in that account has a unique Client ID. Two devices with same Client ID cannot be connected.

```
char username [] = "MQTT_USERNAME";
char password [] = "MQTT_PASSWORD";
char ClientID [] = "CLIENT_ID";
```

Make sure to update this line in the sketch file to include your Arduino board's unique authentication token. It should look similar to this:

```
char username [] = "6e06ae80-a72d-11ea-93bf-d33a96695544";
char password [] = "48f0508728b399702931ec3754551dea9b8a5b24";
char ClientID [] = "d289aa20-aa7e-11ea-b767-3f1a8f1211ba";
```

Copy MQTT credentials in the global void that over the Void setup figure 5.33

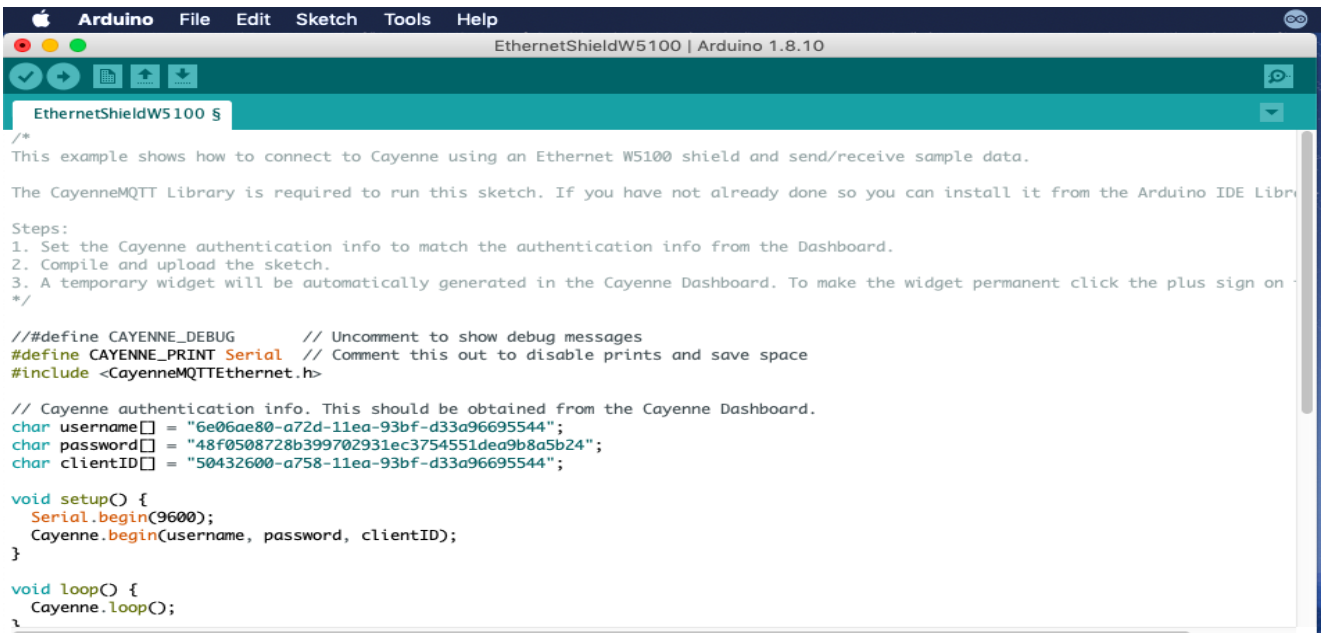


Figure 5.33 MQTT credentials in the global void

Eighth Add a Sensor

Cayenne works with any sensor that is connected to an Arduino, for example Let's add temperature sensor TMP36.

Click Add New > Device / Widget. Figure 5.34

1. Choose Sensor > Temperature > TMP36.
2. We will use Virtual Pin 1 for this example. Choose 1 from the Pin field.
3. Click the Step 1: Sketch File button to view the sketch file. Figure 5.36



Figure 5.34 Main Menu

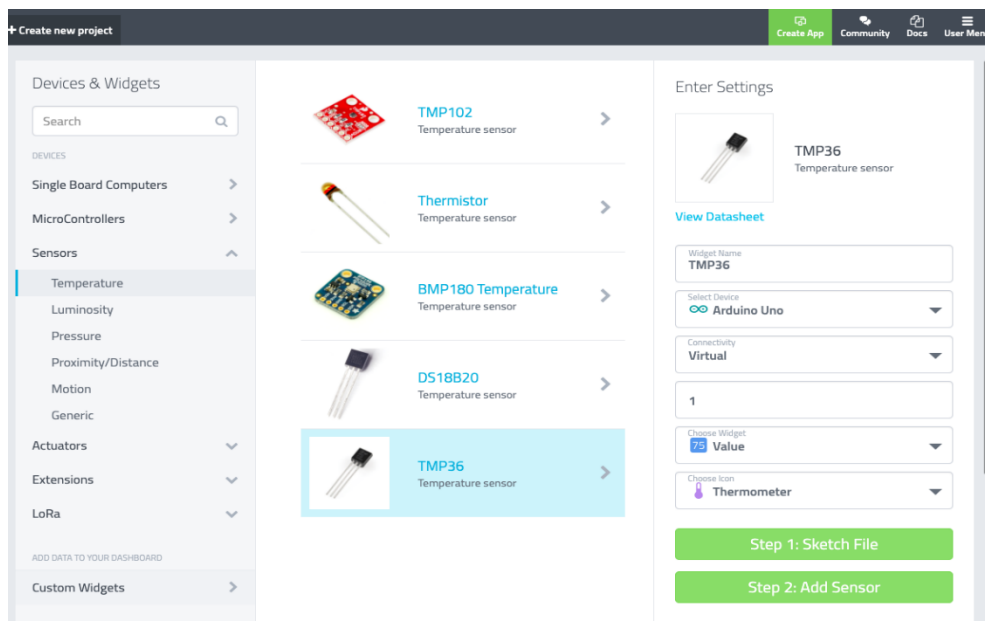


Figure 5.35 Add New Device Panel

Paste the TMP36 sketch file code into the Arduino IDE. After copying & pasting the example sketch files, you will want to double check that your MQTT CREDENTIALS is correct as well as update any pin assignments that appear in the sketch file. Read more about using sketch files. Figure 5.37

In this case, we are using the default Virtual Pin 1 which is already defined in the sketch file, so the sketch file should be OK to use as is. After verifying the sketch file looks good, select Sketch > Upload to upload the sketch file to your device.

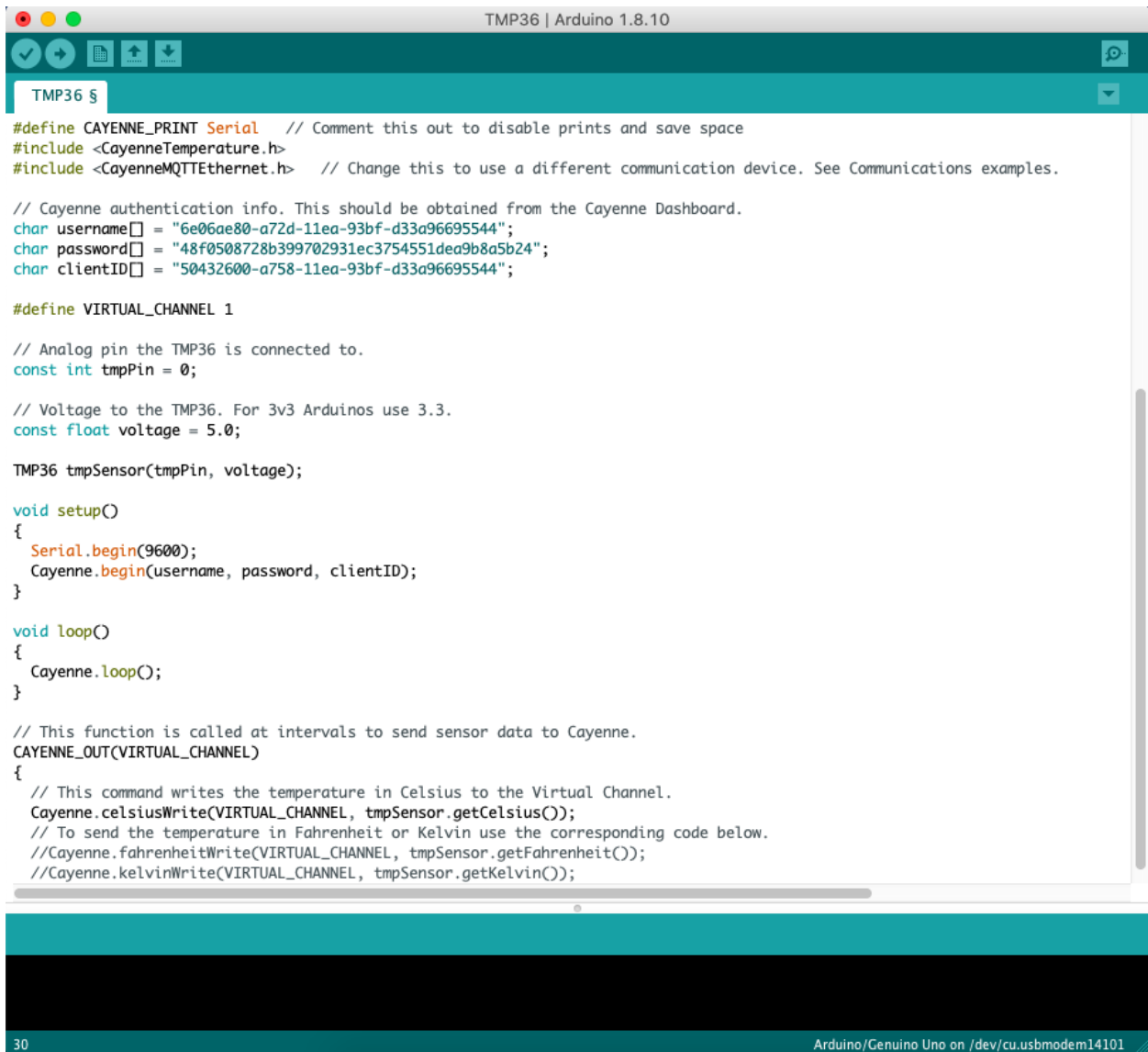


Figure 5.37 Arduino IDE After pasting a code.

In the Cayenne dashboard, you can now click the Step 2: Add Sensor button and the TMP36 widget will be added to your dashboard. You can change widget type and settings by clicking on the cogwheel icon in the top right corner of the TMP36 widget. Figure 5.38

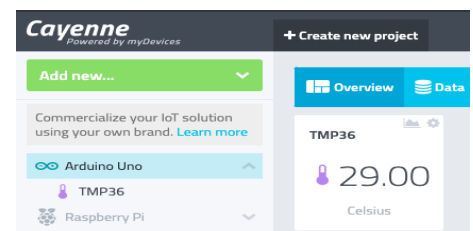


Figure 5.38 Sensor button that recently added.

5.4 Prototype Results

The Prototype is a mini greenhouse contains a Soil, Water tank, Compost tank, Water pump, Drip tube, Shutter, Electrical Devices, and Sensors. Figures 5.20-5.22



Figure 5.39 Prototype Top View



Figure 5.41 Prototype Front View



Figure 5.40 Prototype Back View

Recommendations

- Greatly, since the IoT is a Futuristic modern technology nowadays, tips and guidance must be announced to ensure a better Knowlagent and hints, that hopefully doesn't become a future problem.
- The IoT technology can implement any future electrical device to control or sense device to monitor the measures, So the place is reserved for them in any controller.
- Water must be avoided by all electrical devices.
- Taking consider that a Wi-Fi is alike any type of low power radio waves can be affected by surrounding objects, it gets refraction or reflection, which will lead to delay the response, so the Wi-Fi controller place must be in low distracting effect area.
- The Wi-Fi Covered area is around 100 meters circular around the device, so it makes sure to place the controller in the connected area.
- Soil Probe sensors mustn't insert in all its length in the soil, just only the first three centimeters, because it may lead to a defect in the probe.
- The batteries' life is from 4 days to 7 days since the controller is a low power device and can save electrical energy, it can be charged by any smartphone charger.
- An ON / OFF switch every circuit is provided except the ESP01 circuits because they have DC Power source due to control the relay output, not senses any prop, that's let makes control operation permanent all the time.
- The Compost tank doesn't have a water level sensor because it may be a low amount of liquid or must be solved in a water tank.
- High-speed internet connection is the backbone of every IoT project, so good broadband is recommended to use.
- The solar cell system is very good for the farm, especially if it is in an area far from the electrical feeding infrastructure, and then achieved the totally sources compensation, in one integrated system.
- An Internet sours is variant from an Internet via Wire Gateway (ADSL, ADSL2+, Optical Fiber) or Internet via Satellite Terminals (DVB, SCPC) or internet via cellular (GPRS,3G,4G,5G) according to the region and the availability of the infrastructure in it the internet sours can be selected. If the farm is near a residential area like a city a wire gateway internet is recommended, if the farm is far away from the city but cellular network reaches you the cellular internet is recommended, if the farm is far away area and without infrastructure and cellular network the recommended sours Internet via Satellite.

Appendix

A Green House Solar System

We proposed an Energy Solar System for the Green house to achieve sustainable energy.

Optimum energy consumption and renewable energy utilization reduce environmental impacts and are cost-effective. They are the key aspects of achieving sustainable energy management, such as in the agricultural industry. The contribution of the horticultural section in the global energy demand is approximately 2%, and among its various sections, greenhouses are one of the main systems in modern agriculture that have a great share on energy consumption. [24]

Energy is undoubtedly one of the main drivers of economic growth, and its sufficient supply is the key factor in the development of a country. In recent years, energy demand, particularly electricity, has been increased due to industrialization, modernization, population, and welfare growth. In the past decades, electric power was mainly supplied by fossil fuels, such as oil, natural gas, and coal. Likewise, in the twenty-first century, electricity generation is still heavily dependent on fossil fuels.

This poses environmental hazards, including global warming, greenhouse gas emission, and climate change. [24]

Sustainable energy management is one of the newest research topics and has the utmost importance for all sectors, such as in horticulture. The share of the horticultural section in the global energy demand is 2%.

Hence, sustainable horticulture is one of the current challenging issues in the fields of industrial agriculture and energy consumption.

Among renewable energy sources, solar energy is one of the most promising energy sources owing to its high potential and availability.

Among many solar energy systems, photovoltaic (PV) technology is increasingly competitive and it plays a crucial role in producing clean and stable electrical energy.

Which can be used for various applications, such as for greenhouses. As one of the crucial agricultural sectors with the highest amount of energy consumption, greenhouses have been used for centuries to increase production and control climate conditions.

Components and material

The Solar System components and material is

- Inverters
- Racking
- Batteries

- Solar Panels (PV Modules)
- Main Controller

Connection of the components

As in the figure A.1 Shows the components connected together supporting the different type of loads.

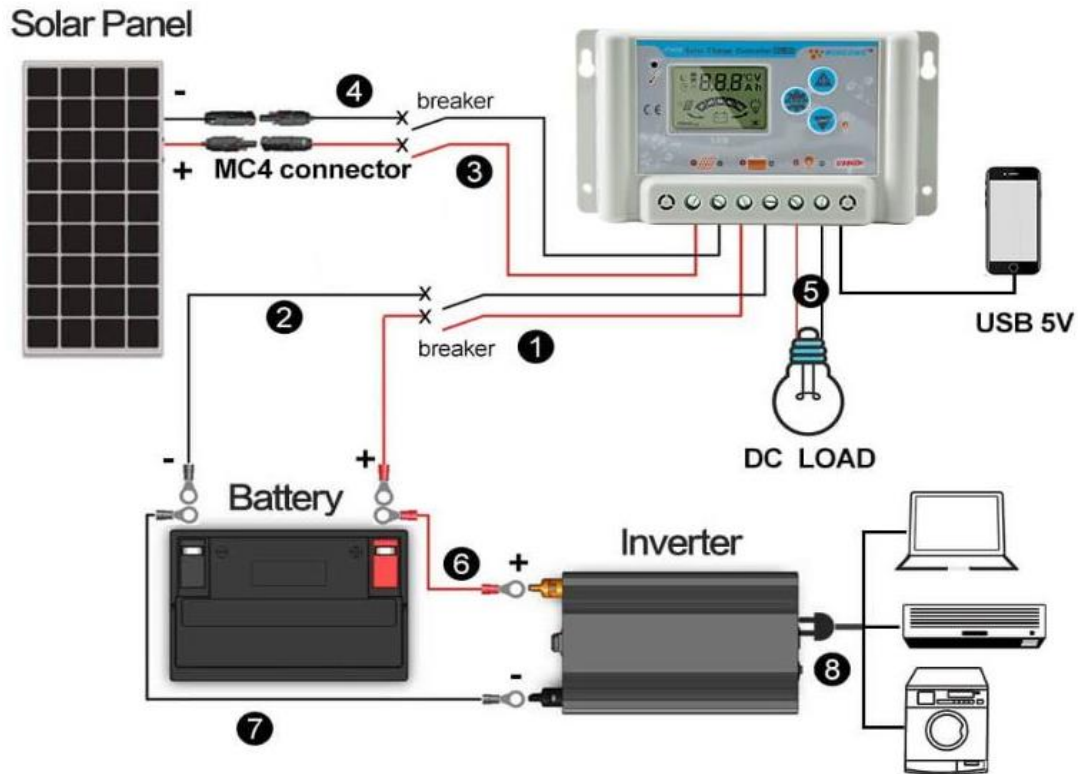


Figure 0.1 Connection of the components

Connect the solar system to the green house

The electrical components can be supplied from the solar system like the municipal electricity source.

Figure A.2 shows how some of the electrical works

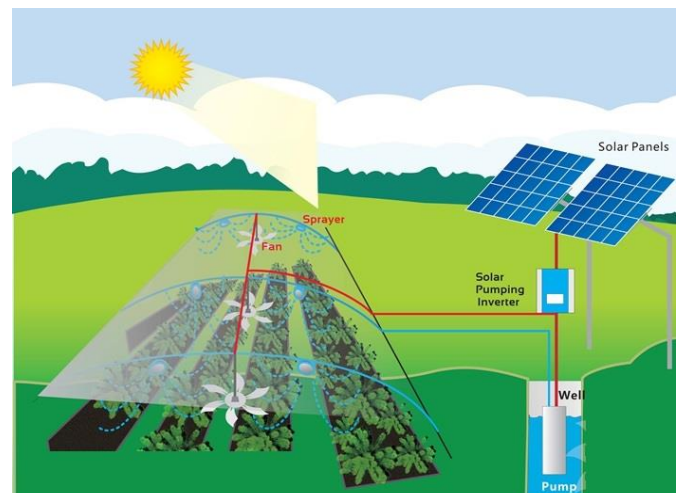


Figure 0.2 Connect the solar system to the green house

Improving Efficiency

- Try to ensure that the panels are south facing
- Make sure they are correctly angled to receive sunlight
- Ensure your greenhouse is well insulated
- Make sure there is no shade covering the panels
- Make sure that there is a space between solar cells figure A.3
- Place all the system component in one panel figure A.4



Figure 0.3 space between solar cells



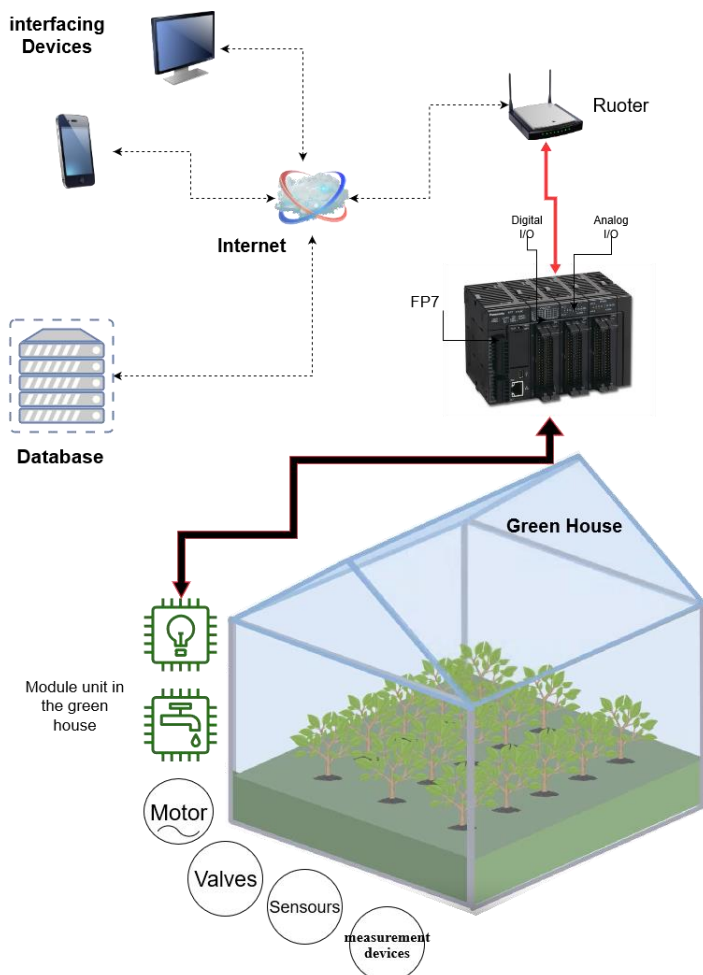
Figure 0.4 component placed in one panel

B The Alternative System

The alternative system that we presented at the beginning of the project

Depending on the idea of using the advanced industrial smart parts because they are more reliable and easier to deal by taking advantage of their software features and Internet transport and the possibility of rapid modification and accelerated high response.

A Panasonic Programmable Controller FP7, and input and output modules for analog and digital signals, that are connected to sensing and measurement devices, electrical valves, and water pump devices, with build-in system application and external database server over the internet connection. [25]



(1) The System Layout

The main part is the Panasonic Programmable Controller FP7 - AFP7CPS31E.

- The Panasonic Multi I/O - AFP7MXY32DWD.
- The Panasonic Analog input and output units - AFP7AD8.
- Panasonic Application's main system.
- Database as a local computer.
- Internet Router.
- Sensors and measurement devices.
- Electrical Motor and liquid valves devices.

Figure 0.5 The System Layout.

(2) System The main Parts

(3) The Panasonic Programmable Controller FP7

It's a smart programmable logic controller that represents a new era of automation control. Visualize worksite conditions by collecting and transferring information. That has a lot of features:

- a. Compact size with room for expansion functions.
- b. Up to 16 different units can be connected to a single CPU.
- c. High-capacity:
SD (SDHC) memory cards up to 32GB have supported a large memory capacity (up to 220k program steps or up to 500k data words), and a high-speed processor (11ns/step).
- d. High-performance:

The processing speed is less susceptible to frequent Ethernet communication. min scan time 1ms, max. 20 μ s for 60k steps.

- e. Local & remote connectivity:

The standard CPU boards with Ethernet interface offer connectivity without limits, from remote programming to monitoring and data logging to FTP server, MEWTOCOL (client/server), Ethernet/IP, and Modbus TCP. Together with the Mini-USB and the RS232C port, it is possible to connect up to 272 devices. Supported services include FTP client/server (file exchange), HTTP Client (data exchange/services with an HTTP server/cloud), and sending e-mails with attachments.

The integrated web server allows access to the variables of the system/program or diagnostic information using a predefined page or a user-defined page created with the graphical tool "Web Creator" based on HTML5 technology. HTML pages can be viewed from any Internet browser even from mobile devices (smartphones and tablets).

f. Security & reliability:

Built-in program backup. Production can resume in the event of a fault. The original program is immediately to hand.

g. Maintenance:

Hour meter operation. The built-in clock/calendar function can be adjusted via Ethernet.

h. Ethernet/IP compatibility:

Models with built-in Ethernet ports add functionality to the CPU unit. Easy connection with all kinds of robots and PLCs enables control and communication

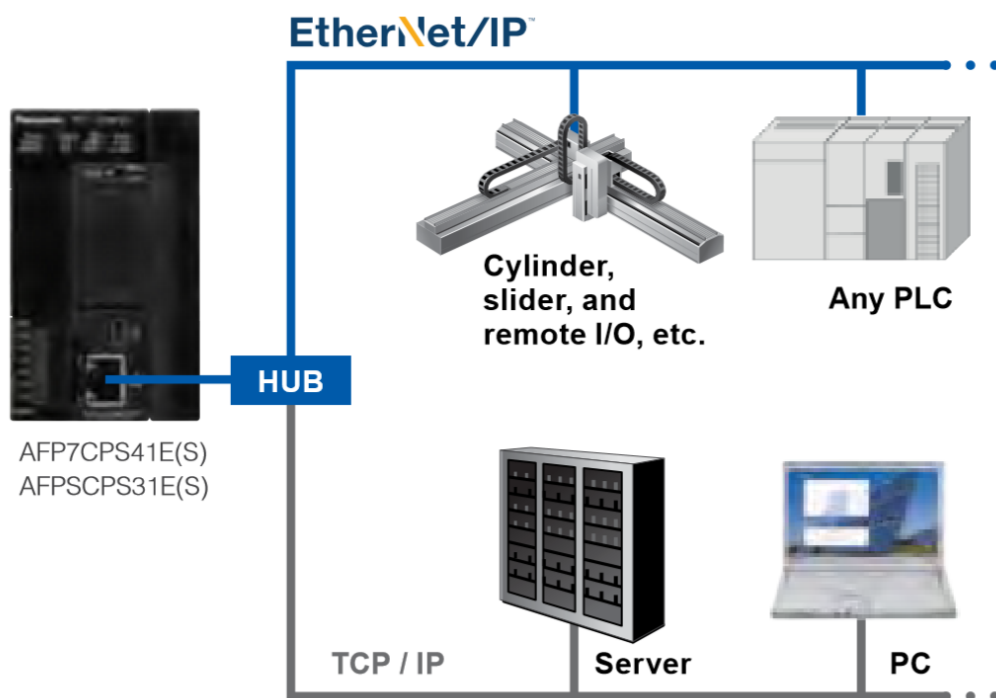


Figure 0.6 Ethernet Connectivity [25]

i. Supports all types of protocols such as Ethernet/IP, MC protocol, and Modbus (RTU and TCP) so that the FP7 can easily be installed in existing production facilities.

j. Low cost compared to other PLC industrial products, while expensive compared to other conventional controllers such as Nude MCU, PIC microcontrollers and Relays

(4) The Panasonic Multi I/O

Multifunctional control is achieved in one unit that supports high-speed counter input, interrupt input, pulse output, positioning output, comparison output, Transistor output NPN, PNP, Differential output, and 5 V, PWM output, Encoder/microcomputer / two-wire system sensor, etc.

(5) The Panasonic Analog input/output

Sampling and data collection in the analog unit that's Ideal for high-accuracy measurement applications because, with the fixed cycle, the analog signal can be held in the buffer, The analog sampling that does not depend on the CPU Sampling and data collection take place in the analog unit so this is ideal for high accuracy measurement applications because, with the fixed cycle, analog signals can be held in the buffer. So, it can do analog buffering leads to High-speed conversion: 25 μ s/Ch. with overall accuracy: $\pm 0.05\%$ F. S. (at +25°C +77°F).

(6) The Panasonic Application main system

Data collected by the FP7 can be displayed in a web browser. Via smartphone or PC, it's easy to check the current state of the worksite. So, there's no need to go to the worksite to check indoor temperature and humidity or the operation of pumps, heaters, and other equipment.

The web browser application can create by Control Web Creator.

This is a graphics creation tool that allows you to easily design web content that is published by the FP7. You can creatively design content by arranging web components such as switches, lamps, and meters on the screen and then set the properties. The content will be linked to information in the PLC without you needing any knowledge of HTML.



Figure 0.7 Panasonic Application main system [25]

Control Web Creator feature:

- a. Components can be arranged by dragging and dropping.
- b. Detailed component settings are easy using properties.
- c. Components do not lose quality when enlarged or reduced and can color them as desired.
- d. Images can be pasted in.

Data collected by the FP7 can be displayed in a web browser. Whether the user is using a smartphone or a PC, it's easy to check the current state of the worksite, so data connectivity can be done by:

- a. WEB Server Function:

Monitor and control the FP7 without the need for dedicated software. Users can check the accumulated data in the FP7 with a browser and send control commands as required.



Figure 0.8 WEB Server function [25]

b. Information updates via e-mail:

Supervise the operation of the equipment via e-mail. Receive and view daily reports as well as get notifications if a malfunction occurs

c. E-mail sending function (SSL-compatible):

Configure the FP7 to send e-mails on a preset schedule or when a preset condition changes in the PLC. The e-mails can be sent with data files attached and are protected by SSL.

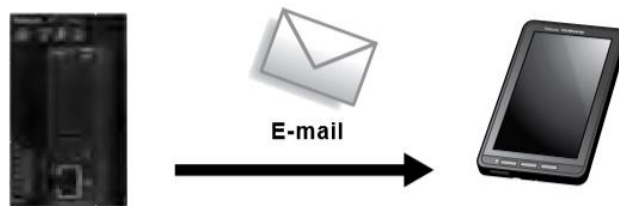


Figure 0.9 E-mail sending [25]

d. Local & remote connectivity:

The standard CPU boards with Ethernet interface offer connectivity without limits, from remote programming to monitoring and data logging to FTP server, MEWTOCOL (client/server), Ethernet/IP, and Modbus TCP.



Figure 0.10 Local & remote connectivity [25]

(7) Database as a local computer

A database that holds all parameters of temperature, water vapor, humidity level, Soil moisture level that's all reserved in schedules stored in large storage devices, with Panasonic Software applications and tools,

Such as:

- A. Control FPWIN Pro it's a PLC Programming Software.
- B. FP OPC Server it's standardized connectivity to FP Series PLCs.
- C. FP Data Analyzer it's a software tool to read and display PLC data.
- D. PCWAY it's a data monitoring, logging, and setting software based on Microsoft Excel.
- E. FP Web Designer it's an easy-to-use editing tool that helps users create websites for visualizing process data collected by the FP Web-Server.
- F. FPGT Loader that's allows you to upload complete programs easily to GT touch panels or FP-Series PLCs without requiring a programming system.

(8) Internet Router

According to connectivity, it must have an internet connection on the farm due to make the Transfer data between the FP7 and the internet and between the internet and server.

A simple ADSL connection of 4 Mbps is enough.

(9) Sensors and measurement devices

It was mentioned in the second chapter

(10) Electrical Motor and liquid valves devices.

It was mentioned in the second chapter

(11) Connectivity principles

Wherever the collected information is needed, the FP7 transmits it, be it to a PC, a server, the cloud, or anywhere else.

Information can be transferred to different types of media:

1st. HTTP(S) client function (SSL-compatible):

Transfer data from the FP7 to a web server for easy viewing with a browser. Send and receive data from multiple FP7 units on a schedule controlled by the FP7. Communicate both inside the firewall on an intranet and outside the firewall to the wider world through the Internet. Allow users from around the world to access the current state of their equipment. [25]

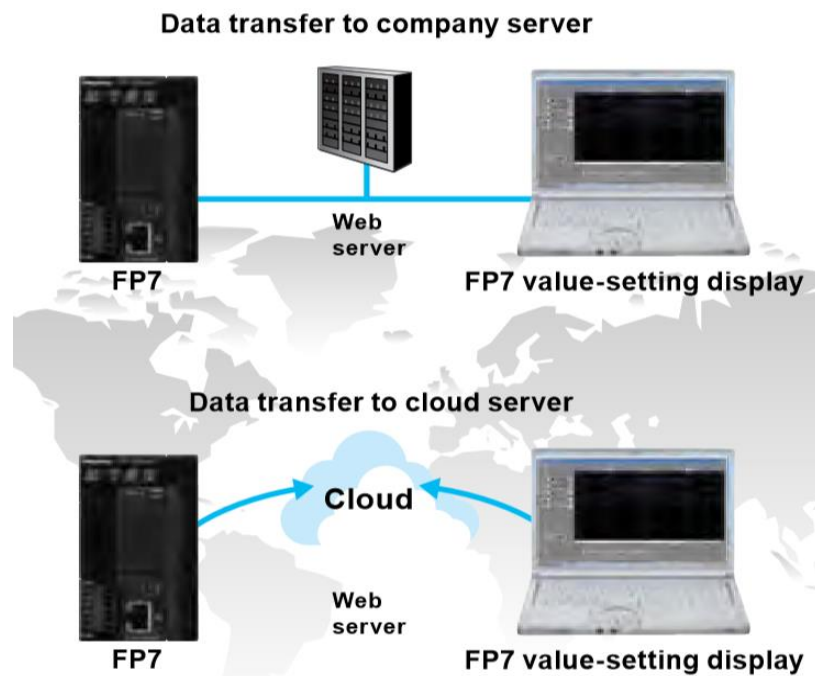


Figure 0.11 HTTP(S) client function [25]

The FP7 can generate and write data files to an FTP server on a PC as well as read data files from the FTP server.

The sessions use SSL, thus protecting IDs and passwords, that allows the PC to read the logging data in the FP7's SD memory card and to write setting values and other parameters.



Figure 0.12 FTP(S) client function [25]

(12) The Algorithm system

Starting the algorithm with reading order to all sensors parameter that connected to the MCU and storing it in the memory, while at the same time a parallel process start to gather the comparison parameter from the database.

Next Process comes the comparing operation between parameters that came from the database, collected from sensors, and modified from the user.

After the comparison test, the action must take in the priority of : first, to install the user input parameters in the database. second, if there it's a difference between the user parameters and what parameters read from sensors the actions will start to apply to run the specific output that will make the parameter the same of comparison.

a time of one minute will take as a delay to make the changes in the parameters by applying the actions. another comparing operation starts to measure the values of sensors parameters are the same as in the database or not.

If yes it's the same well make the next read sensors parameters after every five mints until detects a difference in the values of parameters.

if no, the system will go immediately to comper the database parameters again and reading sensors parameters.

The Algorithmic of all MCU is the same Protocol steps but deferent sensors and deferent Outputs.

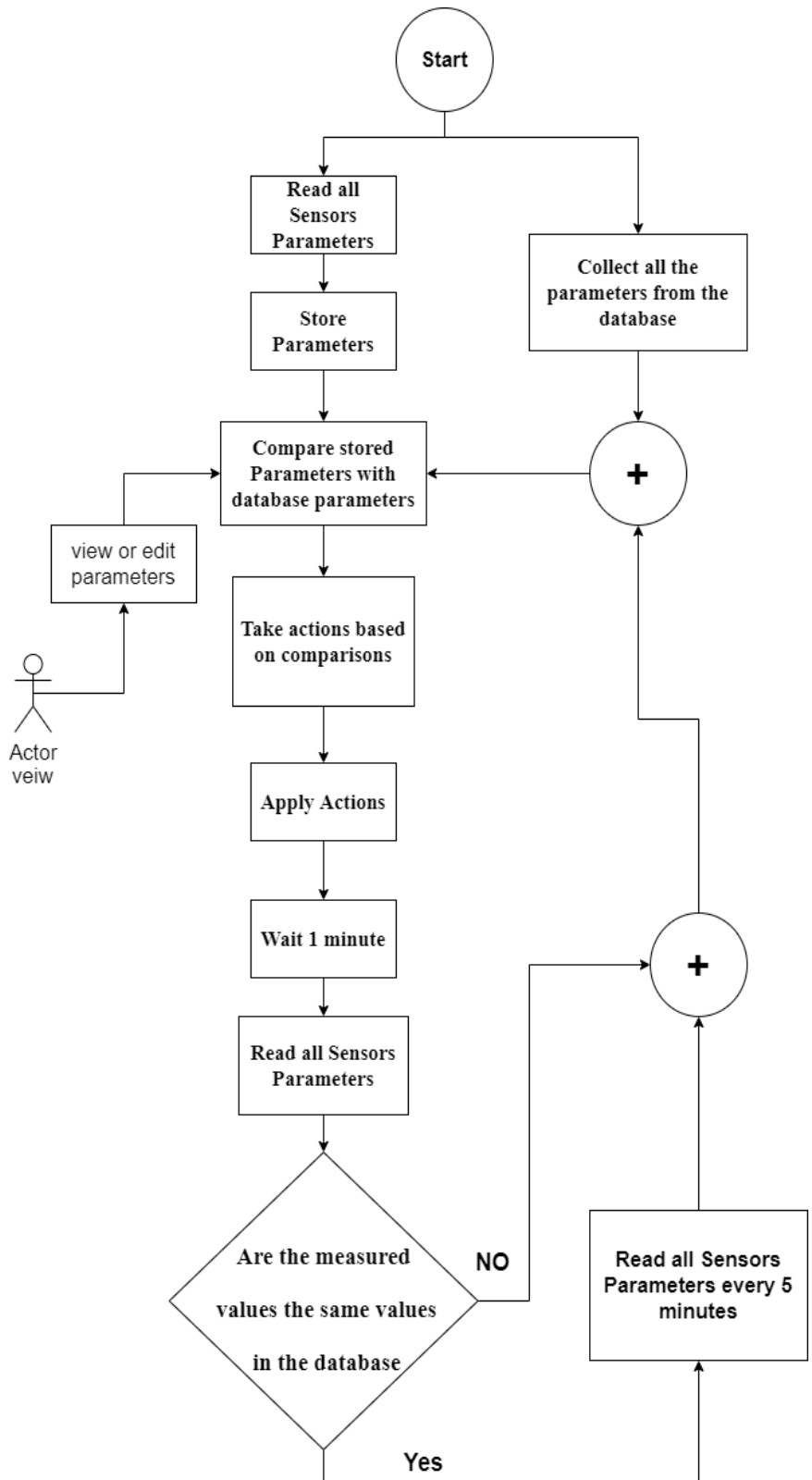


Figure 0.13 Algorithm system

(13) The cost of the system

Table 0.1 The Cost of the alternative system

Element	Availability	Cost (NIS)
Internet IP domain / year	yes	50
Internet Router.	yes	200
Electrical Pump Motors.	yes	1200
Electrical Curtain Motor	yes	100
Electrical Fan Motor	yes	100
Electrical Shelter Motor	yes	100
Valve	yes	400
Relays	yes	7 X 15
Flow Sensor	yes	50
Level Sensor	yes	45
Temperature Sensor	yes	2 X 15
Humidity Sensor	yes	2 X 15
Light Sensor	yes	2 X 15
Soil Sensor	no	120
pH Sensor	no	300
Power supply High voltage	yes	MU supplement
Power supply Low voltage	yes	4 X 30
The Panasonic Programmable Controller FP7	no	3000
The Panasonic Multi I/O.	no	400
The Panasonic Analog input/output.	no	400
The Panasonic Application's main system.	yes	Free
Smartphone	yes	400
Wires	yes	200
Database as a local Computer	yes	600
Total		7980

The Cost Conclusion is the IoT Modules cheaper than the smart PLC system.

References

- [1] S. S. Elmusa, *Water Conflict Economics, Politics, Law and the Palestinian-Israeli Water Resources*, 2nd ed., Rammalla: Institute for Palestine Studies, 1997.
- [2] "PECDAR", "Palestinian Council for Development and Reconstruction", "The problems of the agricultural sector in Palestine," 2018. [Online]. Available: http://info.wafa.ps/ar_page.aspx?id=EoRurKa2392707042aEoRurK. [Accessed 2018].
- [3] ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD), "Adoption Of Technologies For Sustainable Farming Systems," *WAGENINGEN WORKSHOP PROCEEDINGS (SÉMINAIRE DE WAGENINGEN)*, vol. 2, no. 12, 2001.
- [4] M. Yazbak, *The Orange City, Yafa: Culture and Community 1700-1840*, 1st ed., Ramallah, Beirut: Institute for Palestine Studies, 2018.
- [5] Waleed Abdalla, Mohamad Khdair, Mos'ab Ayyash, Asad Issa, "Utilization of Advanced Technology in Greenhouses in Palestine from the Perspective of Agronomists," *Palestinian Journal of Technology & Applied Sciences (PJTA)*, vol. 2, no. 1, pp. 116-127, March 4, 2019.
- [6] A. Chalimov, "IOT IN SMART AGRICULTURE," Eastern Peak, 7 July 2020.. [Online]. Available: <https://easternpeak.com/blog/iot-in-agriculture-technology-use-cases-for-smart-farming-and-challenges-to-consider/>. [Accessed 7 July 2020.].
- [7] Alami, Nermeen; Ewawi, Shahd, "Using Computer Vision for Plant Disease Detection," Palestine Polytechnic University, 1 6 2013. [Online]. Available: <http://scholar.ppu.edu/handle/123456789/695>. [Accessed 7 2013].
- [8] Alhaddar, Alaa; Abuazizeh, Rami; awwad, Osama, "Using Vfd In Pumping System With Scada," 1 5 2013. [Online]. Available: <http://scholar.ppu.edu/handle/123456789/1817>. [Accessed 6 2013].
- [9] Patel, Keyur & Patel, Sunil & Scholar, P & Salazar, Carlos, "Internet of Things-IoT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges.," *International Journal of Engineering Science and Computing*, vol. 6, no. 5, pp. 6122-6213, May 2016.
- [10] S. S. Elmusa, *Negotiating Water: Israel and the Palestinians*, 1st ed., Ramallah, Beirut: Institute for Palestine Studies, 1996.
- [11] Rubinho, "NEW INVENSYS CP6 WATER PUMP HOOVER VACUUM," HOFFA78ELMOREA1267A A great WordPress.com site, 8 may 2011. [Online]. Available: <https://hoffa78elmorea1267a.wordpress.com/2011/05/08/new-invensys-cp6-water-pump-hoover-vacuum/>. [Accessed 9 may 2011].
- [12] A. ®, "Plastic Water Solenoid Valve," Adafruit ®, [Online]. Available: https://media.digikey.com/pdf/Data%20Sheets/Adafruit%20PDFs/997_Web.pdf.

- [13] D. Kruger, "Components101," 2017. [Online]. Available: <https://components101.com/ultrasonic-sensor-working-pinout-datasheet>. [Accessed 18 September 2017].
- [14] Posifa Technologies, "Components101," 2020. [Online]. Available: <https://components101.com/news/plf2000-cost-effective-mems-liquid-flow-sensors-for-high-accuracy-and-low-maintenance>. [Accessed 14 April 2020].
- [15] Aideepen Electronics, "guuds," 2017. [Online]. Available: https://www.guuds.com/product/GA-1028A__Soil-pH-Meter-3-in-1-Moisture-Sensor-Meter-Sunlight-pH-Soil-Test-Kits-test-function-for-Home-and-Garden-Plants-Farm-Indoor-Outdoor-Use.html. [Accessed 2017].
- [16] Verical Electronics, "Components101," 2017. [Online]. Available: <https://components101.com/ldr-datasheet>. [Accessed 30 October 2017].
- [17] Aideepen Electronics, "Aideepen," 2018. [Online]. Available: https://www.aideepen.com/products/12v-soil-moisture-relay-module-electronics-soil-moisture-sensor-humidity-detection-relay-control-automatic-watering-for-arduino?_pos=2&_sid=5ae6a1b7c&_ss=r. [Accessed 2018].
- [18] Components101, "Rain drop Sensor Module," Components 101, 20 December 2019. [Online]. Available: <https://components101.com/sensors/rain-drop-sensor-module>. [Accessed 20 December 2019].
- [19] Seeed Technology Co., Ltd, "Components101," 2018. [Online]. Available: <https://components101.com/dht11-temperature-sensor>. [Accessed 5 January 2018].
- [20] ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD., "ESP8266 Hardware Design Guidelines," 2019. [Online]. Available: <https://www.espressif.com/en/support/documents/technical-documents>. [Accessed 01 10 2019].
- [21] SONGLE Electronics Co.Ltd, "Components101," 2017. [Online]. Available: <https://components101.com/5v-relay-pinout-working-datasheet>. [Accessed 26 September 2017].
- [22] Isocom Electronics, "Components101," 2019. [Online]. Available: <https://components101.com/ics/moc3041-zero-cross-triac-driven-optoisolator>. [Accessed 12 April 2019].
- [23] KAYO Electronics, "Components101," 2019. [Online]. Available: <https://components101.com/articles/different-types-of-batteries-and-their-uses>. [Accessed 21 August 2019].
- [24] T. Alinejad, M. Yaghoubi, A. Vadiiee, "Renewable Energy of Thermo-vironomic assessment of an integrated greenhouse with an adjustable solar photovoltaic blind system," *Elsevier Ltd.*, vol. 1, no. 13, pp. 0960-1481, 2020.

- [25] Oaza Kadoma, Kadoma-shi, Panasonic Systems Electromechanical Control Business Division 1006, Osaka industrial, Japan: Panasonic Documentations, 2017.
- [26] GSM Association Connected Living Programme, "Understanding the Internet of Things (IoT)," July 2014. [Online]. Available: <https://www.gsma.com/iot/>.
- [27] Agricultural Media Research and Extension Centre, "Agricultural Economics and Farm Management," *ARPJN Journal of Agricultural and Biological Science*, vol. 3, no. 2, 2010.
- [28] Schneider Electric, "Components101," 2019. [Online]. Available: <https://components101.com/articles/relays-and-contactor-types-working-and-difference-between-them-0>. [Accessed 9 September 2019].
- [29] S. Roy, *The Gaza Strip: The Political Economy of De-development*, 1st ed., Ramallah, Beirut: Institute for Palestine Studies, 1995.