DESIGNING AN ARDUINO MEGA 2560 MICROCONTROLLER FOR DRIP IRRIGATION SMART URBAN FARMING APPLICATION WITH IOT INTERFACE

Moza Aurelia Aprisma Priyanto[1], Erna Sri Sugesti[2], Paulus Suwanto[3]
[1,2] Telkom University, Bandung
[3]Mechatronic-Consultant PT PhiMatic Otomasi Indonesia
mozaurelia@students.telkomuniversity.ac.id[1], ernasugesti@telkomuniversity.ac.id[2], suwantodr@gmail.com[3]

Abstract

Agriculture is the backbone of Indonesia's economy. However, due to the COVID-19 pandemic, the country's economy becomes very troublesome. Food supply is one of the main necessities during this pandemic, the crop prices nowadays are increasing which made some people restless and prefer to eat unhealthy cheap foods. In other cases, water resources on our planet efficiently decrease due to various reasons like population growth, rapid urbanization, and climatic change.The emergence of modern agriculture through Smart Urban Farming using the IoT helps people to reduce the usage of natural resources, grow plants easily, and optimize the water consumption.This Final Project discusses about Drip Irrigation for Smart Urban Farming which focuses on controller design. Using drip irrigation systems have the potential of saving the water and nutrients directly to the plant's root zone, in the right amounts, at the right time, so each plant gets exactly what it needs to grow optimally. This irrigation system provides pH and soil moisture sensors. The system can water the plants automatically and semi-automatically by using the parameters of the sensors. The sensor's data can be monitor and seen through the smartphone.The results of the drip irrigation testing on the plants, the system can properly perform automatic and semi-automatic scheduling according to the specified time, it can generate a 100% success rate for the scheduling scenarios. The system requires 66.412 L of water in 60 seconds to produce approximately 165.2 mL water droplets for each plant.

Keywords : Drip Irrigation, Smart Urban, Agriculture, COVID-19 pandemic

Introduction

Agriculture is the art work and technological understanding of cultivating the soil, growing vegetation, and elevating livestock. It includes plant and animal products for humans to use and their distribution to markets. Over the centuries, the growth of agriculture contributed to the upward thrust of civilizations. Indonesia is ranked as the 4th most populated country in the world, with the top manufacture of agriculture products.

As Indonesia's digital economic system continues developing, COVID-19 was first stated in Wuhan's city at the end of 2019 and has spread unexpectedly to numerous countries. Food supply is one of the primary necessities during this pandemic [1]. Unfortunately, crop prices these days are growing [2], Researcher of Center for Indonesian Policy Studies (CIPS) in November 2020, Galuh Octania said, "Food prices will increase next year due to the COVID-19 pandemic." Which made some people restless and prefer to consume cheap unhealthy foods. Survey show that vegetable consumption is still low, even though people aware of the importance of vegetable intake for health reason [3]. In other cases, World Resources Institute (WRI) said, "Indonesia has the mischance to become a country with a high level of water crisis." It when's water resources on our planet efficiently lower due to numerous reasons like population growth, rapid urbanization, and climatic change [4].

This Final Project is objectives to increase the irrigation system for smart home irrigation system. The type of microcontroller for the Drip Irrigation System is Arduino Mega 2560 and ESP8266 as a Wi-Fi module which makes it easy for customers to connect the application with an irrigation system. Hence, the emergence of this Smart Irrigation System, it's expected to make it easier for people to develop vegetation easily, grow crops at home, and save water consumption during the COVID-19 pandemic.

Basic Concepts

Modern Agriculture

Modern agriculture is an evolving technique of agricultural enhancements and farming practices that help farmer's growth performance and decrease the quantity of natural resources like water, land, and electricity essential to fulfill the world's meals, fuel, and fiber needs. The agribusiness, in-depth farming, organic farming, and sustainable agriculture are different names of modern agriculture. Modern agriculture advanced our affordability of meals, increases the meals supply, ensured meals safety, will growth sustainability, and produces more biofuels. But at the same time, it additionally outcomes in environmental issues due to the fact its miles based on high input–high output method using hybrid seeds of excessive yielding variety and considerable irrigation water, fertilizers, and pesticides.

Smart Irrigation System

Smart irrigation systems are a combination of advanced technology of sprinklers with nozzles that enhance coverage and irrigation controllers which can be watering and water conservation systems that monitor moisture-associated conditions on your home and automatically adjust watering to the greatest levels. Unlike traditional irrigation controllers that perform on a preset programmed schedule and timers, smart irrigation controllers monitor weather, soil conditions, evaporation, and plant water use to automatically adjust the watering schedule to actual conditions of the site [10].

Hardware Used

There is hardware used for this final project to construct a system that has been designed, is the hardware that has been decided on according to its respective criteria with each hardware has its own continuity and role.

1. Arduino Mega

Arduino Mega 2560 is a circuit board with an Atmega 2560 microcontroller chip and has the finest quantity of pins among all other Arduino types. The feature of using Arduino Mega may be very suitable for making projects which have a huge space capacity in the circuit. Larger memory capacity as compared to other varieties of Arduino makes Arduino Mega suitable for projects that use many modules at once.[21]

2. NodeMCU ESP8266

NodeMCU ESP8266 is a microcontroller module designed with ESP8266 in it. ESP8266 serves for Wi-Fi network connectivity among the microcontroller itself and the Wi-Fi network. NodeMCU based on Lua programming language however can also use Arduino IDE for programming.[10]

3. pH Meter

Soil fertility is the ability of the soil to provide nutrients, water, and oxygen in a balanced state for plants. This ability is served by the physical, chemical, and organic properties of the soil. From a chemical factor of view, soil fertility method the ability of soil to provide sufficient nutrients for plants (Setijono. 1986, White. 1987). Soil chemical conditions consist of soil reactions (soil pH), KTK, base saturation, organic matter, abundance of nutrients, nutrient reserves, and availability to plant growth.

4. Soil Moisture

Soil moisture is the quantity of water retained withinside the soil after excess water is drained, if the soil has a high-water content, then excess groundwater is decreased through evaporation, transpiration, and underground transpiration. Standard or reference in measuring soil moisture, particularly the American Standard Method (ASM).

5. Sensor DHT 22

The DHT 22 sensor is to measure air temperature and humidity as well as a type thermistor to measure temperature, a humidity sensor with resistive characteristics to adjustments in water content in the air and a chip inside which performs several conversions. Analog to digital and outputs in a single-wire bidirectional format [10].

6. Module ADS1115

The ADS1115 module is a 16-bit ADC or Analog to Digital Converter module,, so it has a better accuracy rate than the Arduino analog port which only has a 12-bit resolution. This ADS1115 module has 4 input channels, which may be configured for Single Ended or Differential measurement modes.

7. Flow Meter

Flow meter itself is a device used to recognize the significance of all factors contained in a material flow in the form of air, liquid, or powder. The aspect measured through this flow meter is the flow rate or flow speed and the volume or total mass of the material flowing at a certain period[12].

8. Relay 12v

Relay is a transfer (Switch) that's operated electrically and is an Electromechanical component inclusive of 2 fundamental parts, particularly Electromagnetic (Coil) and Mechanical (switch contact). Relays use the electromagnetic principle to move the switch contacts so that with a small electric current (Low Power) they can conduct higher voltage electricity. Figure 2.12 is an instance of a Relay.

9. Solenoid Valve

Solenoid valve is an extra component in an automatic transmission transport. This component is established on the valve body. As the name suggests, the solenoid valve works as a valve to control the flow of oil to the valve body. That way, the oil deliver remains fulfilled, and the transmission equipment shift can run smoothly.

10. Clamp Meter

Digital Clamp Meter or better known as tang ampere or Ampere Meter is a way of measuring electric current without having to cut off the current path. Ampere pliers commonly have greater feature than being able to measure the electrical current of the ampere, tang can also be used to measure a voltage or measure the value of a electric current [12].

Model System Design

This chapter describes the each sub-system in the design of the device which divided into 2 methods, specifically Automatically and Semi-automatically scheduling.

Fig.1. Main System Design

Figure 1. explain the primary system design work flow of the microcontroller into 2 methods.

1. Automatic Scheduling

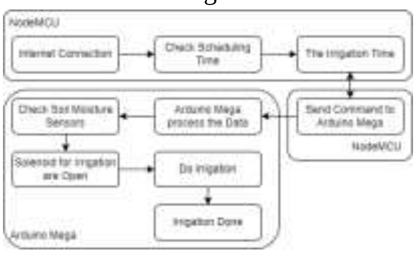

Figure 3.2 Automatic Scheduling Blockdiagram

Figure 3.2 display automatic scheduling is already set on its own system to do watering irrigation. This automatic scheduling method only do the water irrigation and doesn't require sorting the acidity of the treatment. The system design for scheduling methods is running at 07.00 AM and 17:00 PM based on the NTP time.

2. Semi-automatic Scheduling

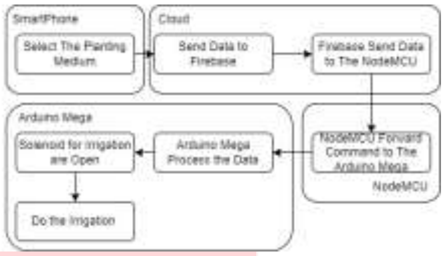

Figure 3.3 Semi-automatic Scheduling Blockdiagram

Figure 3.3 display the semi-automatic scheduling works if the system delivers notifications to the smartphone. Semi-automatic scheduling is devided into 2 parameters, the first one is pH meter and the second one is soil moisture sensor. The differentiator is the indicator of the referrer. If the pH meter suggests the characteristics of acidic pH, then the irrigation could be executed by treatment while the moisture parameters if the plant in the planting medium suggests the characteristics of dryness, then irrigation could be executed with the water.

Overall Device Schematic

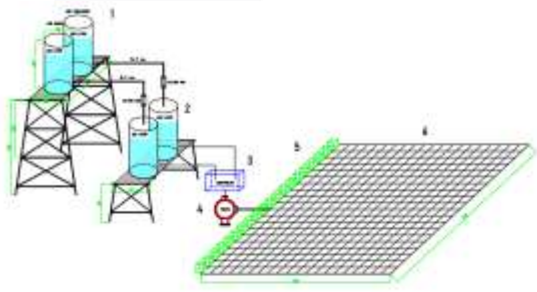

Fig.2. Overall Device System

Figure 2. is the overall device system layout and will explain below:

- In Figure 2. part 1 there are 2 drums, the first drum consists of water and the second drum consists of treatment. The drums will release water right all the way down to the another drum for water filter. Each drum contains 90 litters of water for backup.
- In the part 2, the water flowing from the drums part 1 will be filtered first and will flow to the next stage with the assist of a pump.
- In the part 3, is a controller for the plant irrigation. The controller that will determine which irrigation to use from the 2 drums in the previous stage only one will flow, can't both flow simultaneously.
- In the part 4, if the controller has already determined which water will flow, then the pump will execute the water from the drum to the next stage.
- In the part 5, the solenoid valve will open if the controller has provided access flow the water to the planting medium.

- be explained the part 6, is the planting medium, wherein the solenoid valve has been given access by the controller, then the system will do the water irrigation.

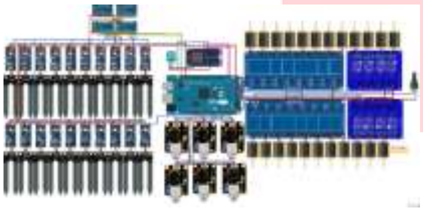

Fig.3. Mirocontroller Schematic

Testing and Analysis

Data Transmission

The first test is accomplished to discover that the system built has been well-connected and get the data accurately. The records that have been sent through the sensor must be obtained by the Arduino Mega due to the fact the Arduino Mega serves as a controller between the sensor and other components. There are 5 connectivity among sensors, namely.

1. The Connection between Arduino Mega to NodeMCU

The Arduino Mega will receive data from the sensors, and it will be dispatched to NodeMCU, from it will be transferred to the Database and can be seen on the smartphone, the following records transmission results from Arduino Mega to NodeMCU.

Table 4.1 The Result of The Sending Data from Arduino Mega to NodeMCU

Test	Soil Moisure																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Test 1	N	N	L	N	L	L	L	L	N	L	L	N	L	L	H	H	N	H	H	H
Test 2	L	L	H	H	N	N	L	L	H	N	L	L	L	N	N	N	N	N	N	L
Test 3	N	L	L	N	H	H	L	H	H	N	H	H	N	H	H	N	N	N	N	L

Test	Ph Meter																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Test 1	4	3	3	6	5	5	6	4	3	3	6	4	6	5	5	4	5	5	6	6
Test 2	4	5	6	6	4	4	5	5	6	6	5	5	6	4	4	6	5	6	5	4
Test 3	6	6	5	5	6	6	5	6	5	5	6	5	4	3	3	6	4	4	5	5

Test	Status Solenoid																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Test 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Test 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Test 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 4.1 is the data transfer from the Arduino Mega to NodeMCU, the data consists of the status of the solenoid valve, soil moisture sensor, pH meter and water pump status. If the connection between Arduino Mega and NodeMCU disconnected, then the data will not arrive.

Table 4.2 Receiving Data from Arduino Mega to NodeMCU

Test	Soil Moisture																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Test 1	Normal	Normal	Low	Normal	Low	Low	Low	Low	Normal	Low	Low	Normal	Low	Low	High	High	Normal	High	High	High
Test 2	Low	Low	High	High	Normal	Normal	Low	Low	High	Normal	Low	Low	Low	Normal	Normal	Normal	Normal	Normal	Normal	Low
Test 3	Normal	Low	Low	Normal	High	High	Low	High	High	Normal	High	High	Normal	High	High	Normal	Normal	Normal	Normal	Low

Test	Ph Meter																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Test 1	4	3	3	6	5	5	6	4	3	3	6	4	6	5	5	4	5	5	6	6
Test 2	4	5	6	6	4	4	5	5	6	6	5	5	6	4	4	6	5	6	5	4
Test 3	6	6	5	5	6	6	5	6	5	5	6	5	4	3	3	6	4	4	5	5

Test	Status Solenoid																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Test 1	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Test 2	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Test 3	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off

Table 4.2 is a part of receiving data given by the Arduino Mega. The records will be received by NodeMCU and will then be used as information in the form of humidity conditions in each planting medium, pH sensor, solenoid valve status and the status of the pump.

2. The Connection between Arduino Mega to pH Meter

On this data transmission, the pH Meter will send analog data to the Arduino Mega, after the data is compressed through the Arduino Mega will be calculated like the image in chapter 3 about the calibration of the pH meter sensor. The data that has been processed by the calculation will pop out in the shape of records of the level of acidity in the ground, the subsequent is the result of connectivity between Arduino mega to pH meter.

Testing	Media																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
day 1	4	3	3	4	5	4	4	4	3	3	3	4	4	5	4	4	4	4	5	5
day 3	6	6	6	6	6	6	7	6	6	6	7	6	6	6	6	6	6	6	6	6
day 5	6	6	6	6	5	5	6	6	6	6	6	6	6	5	6	6	6	6	6	6

Fig.6. Example of Receiving data from pH meter to Arduino Mega

Figure 6. display the result of transport between the pH meter sensor to the Arduino Mega. The results will be saved and sent to NodeMCU and displayed in the Android app.

3. The Connection between DHT 22 to NodeMCU

The connection between the relay and the Arduino Mega will work if the Arduino Mega gives an order to the relay in the shape of a command to perform Automatic Scheduling or Semi-automatic scheduling. The following is the result of the connection between Relay and Arduino Mega.

Test	Sensor DHT22	
	Temp	Hum
Test 1	30.2	47.1
Test 2	28.8	50.4
Test 3	29.1	48.8
Test 4	30.1	54
Test 5	31.7	57.6
Average	29.98	51.58

Fig.7. Example of Receiving data from DHT 22 to NodeMCU

Figure 7. is an example when DHT 22 sends information on the humidity and temperature of a room. Shown with the humidity of the room is 57.70% with the air temperature in the room reaching 29.7 ° C.

4. Connection between Relay to Arduino Mega

The connection between the relay and the Arduino Mega will work if the Arduino Mega gives an order to the relay in the form of a command to perform Automatic Scheduling or when Semi-automatic scheduling. The following is the result of the connection between Relay and Arduino Mega.

Test	Status Solenoid																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Test 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Test 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Test 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fig.8. Example of Receiving data from Relay to Arduino Mega

Figure 8. is the result of the connection between relay and Arduino Mega. Relay will provide feedback in the form of numbers 1 or 0. Relay will give feedback in the form of 1 if the relay condition is OFF and the value of 0 means relay at the ON conditions.

5. The Connection between ADS1105, Soil Moisture and Arduino Mega

To use the Soil Moisture sensor in this system, the ADS1115 module is used to add analog pins because the pinout on the Arduino Mega is very limited.

Medias	Sensor Soil Moisture	Percentage	Indicator
1	13952	57%	High
2	15408	53%	High
3	8272	75%	Low
4	15264	53%	High
5	7648	77%	Low
6	9696	70%	Normal
7	12064	63%	Normal
8	9920	70%	Normal
9	10160	69%	Normal
10	14048	57%	High
11	9360	71%	Low
12	9648	71%	Normal
13	12016	63%	Normal
14	10160	69%	Normal
15	2752	92%	Low
16	9760	70%	Normal
17	692	32%	High
18	670	35%	High
19	857	16%	High
20	864	16%	High

Fig.9. Example of Receiving data Sensor Soil Moisture to Arduino Mega

Figure 9. display the receiving data soil moisture sensor to Arduino Mega. The data can be processed by Arduino Mega, and the result will be in the form of moisture levels from the soil, the subsequent is the result of data processing from the Arduino Mega Sensor.

Automatic Scheduling Testing

The soil used in this test will be divided into types, specifically dry soil, and wet soil conditions. The purpose of this soil is to discover whether the soil moisture sensor can examine the soil conditions correctly or not. Measuring soil with those conditions will be compared to Soil Analyzer. This test was performed during 5 experiments with different soil conditions so that the soil moisture sensor can be examined for truth. Here are the outcomes of the test using 3 scenarios, as follows.

1. Dry Soil Scenarrios

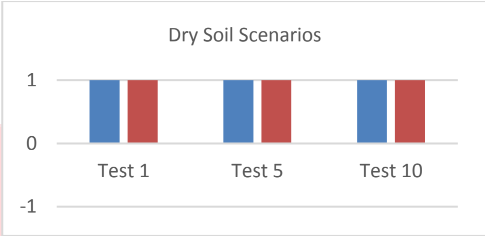

Fig.11. Comparison between sensor soil moisture with Digital Soil Analyzer in Dry Soil Scenarrios

Information:

- Blue Color: Sensor Soil Moisture
- Orange Color: Digital Soil Analyzer

Figure 11. display the comparison between soil moisture sensor and digital soil analyzer in dry soil scenario. "1" value on the graph shows the characteristic conditions on the soil are dry, and "-1" value on the graph shows that the characteristic condition on the soil is wet. After 20 checks using soil moisture sensors obtained the average result and the comparison with the outcomes of the soil analyzer is as expected.

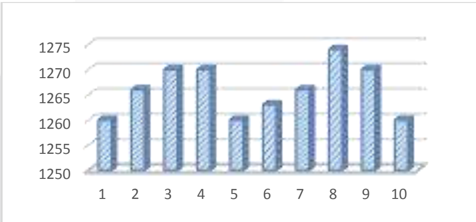

Fig.12. Duration for Automatic Scheduling with Dry Soil Scenarios

Figure 12 is the result of measuring watering duration if all planting mediums are dry. Watering is done for 60 seconds. The result acquired after testing was that the average for Automatic scheduling watering was 1270.4 seconds.

2. Zigzag Scenarios

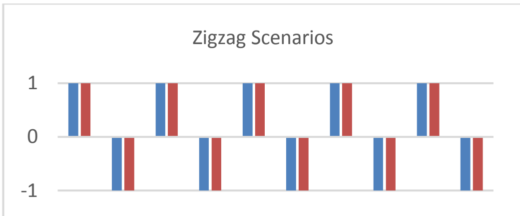

Fig.13. Comparison between sensor soil moisture with Digital Soil Analyzer in Zigzag Scenarrios

Figure 13 shows the comparison between soil moisture sensor and digital soil analyzer in zigzag scenario. The outcomes confirmed that the soil moisture sensor when established with zigzag scenarios at the planting medium display the same outcomes because the digital soil analyzer with a similarity rate of 100%.

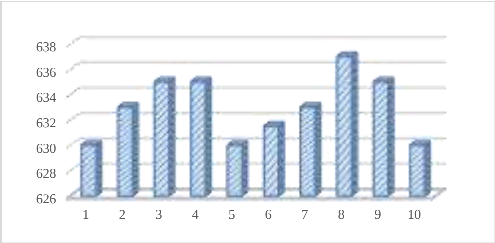

Figure 14 Duration for Automatic Scheduling with Zigzag Soil Scenarios

Figure 14. is the result of measuring the duration of watering if the conditions of the planting medium with conditions are half dry and half wet. Watering is performed for 60 seconds. The result obtained after testing is that the average for Automatic scheduling watering is 645.4 seconds.

3. Wet Soil Scenarrios.

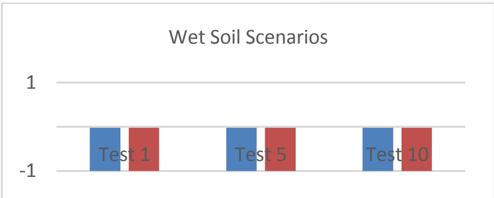

Fig.15. Comparison between sensor soil moisture with Digital Soil Analyzer in Wet soil Scenarrios

Figure 15 describes the comparison between soil moisture sensor and digital soil analyzer in wet soil scenario. The results shows that soil with wet conditions compared to digital soil analyzer tools is the identical.

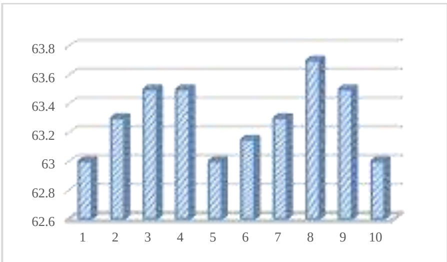

Fig.16 Duration for Automatic Scheduling with Wet Soil Scenarios

Figure 16 is the result of measuring watering duration if the conditions of planting medium with wet conditions. Watering is done for 60 seconds. The result obtained after testing was that the average for automatic scheduling watering was 63 seconds.

Semi-automatic Scheduling Irrigation

Semi-Automatic watering tests are completed via smartphone, users who can set more details, if during the day there are plants that are dry and need water, users who have the application can water plants with certain medias such as if the plants in media number 1 lack water, the user the simplest needs water to give orders to the application for media number 1 to be watered. The watering will be done for 30 seconds and if the watering is not enough then the user simply needs to give the command again.

1. Semi-Automatic watering testing for plain water

This test is done to find out if plants that have been watered scheduling in the morning or evening experience water shortage due to extreme weather or malfunction in the designed system.

Table1. Irrigation Semi-Automatic Testing with Ordinary Water

Testing	Media																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Test 1	1	1	1	-1	-1	1	-1	-1	1	1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1
Test 2	-1	-1	-1	-1	-1	-1	-1	-1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Test 3	1	-1	-1	-1	1	-1	-1	-1	1	1	1	-1	-1	1	-1	-1	-1	1	-1	1
Test 4	-1	-1	1	1	-1	-1	1	-1	-1	-1	-1	1	1	-1	-1	-1	1	-1	-1	-1
Test 5	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1
Test 6	1	1	-1	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	1	-1	1	-1	-1	-1	-1
Test 7	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	1	-1	-1	-1	1	-1
Test 8	1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	-1	-1	1	-1	-1	-1
Test 9	-1	1	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1
Test 10	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	1

Information:

- 1 = Dry
- - 1 = Wet
- Blue Color = There is no irrigation needed
- Yellow Color = Do the Irrigation

This test is performed to discover if plants that have been watered scheduling in the morning or evening due to extreme climate or malfunction in the designed system.

2. Semi-Automatic Watering uses pH Sensor Parameter

Further test will be executed to check the soil pH using a pH meter sensor. This test goals to discover the acidity levels of the soil in the planting medium. If the pH level in the soil is too acidic (less than 5) the plants will be watered using water treatment so that the pH content in the soil becomes elevated.

Planting medium that has been watered by water treatment is expected to rise more than or equal to 6 so that the plant becomes healthful and the pH in the planting medium is maintained. The following are the results of tests of the pH meter measurement.

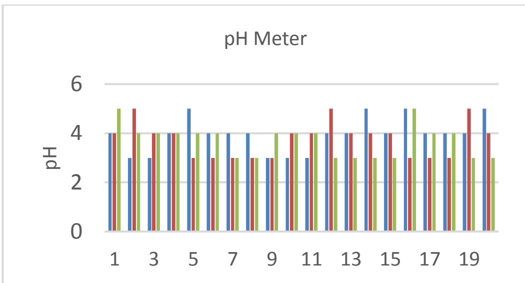

Fig.16. The pH meter sharpener on planting medium

From the previous tests, seen in the figure 16 shows that on the first day of measurements, all plants in the planting medium experience acid pH levels below 5, so the watering treatment will be performed manually using an Android Smartphone.

Then in the next 3 days, there was no decrease in pH in the soil in each planting medium. For the next day, there are some soils that experience a decrease in soil pH acidity, so it must be watered by water treatment so that the pH in the soil increases.

4.2.4 Power Consumption Used

There is a system built, all electricity connected to components such as Solenoid, Water Pump, and Relay (12 Volts) comes from Power Supply DC with a voltage of 12 Volts 5 Ampere, while for Microcontroller Mega 2560 get electricity from Power Bank or from laptop with voltage of 5 Volts. NodeMCU will be connected from Arduino Mega because NodeMCU only requires a voltage of 5 volts. DHT22 will get a ration from NodeMCU.

Fig.17 Clamp Meter Testing On System

The result obtained when the system is all on is 0.17 Ampere. The result is that when at the time of scheduling with the dry land scenario, it will occur that all relays will light up alternately from the first media to the last media.

1. This electrical voltage is obtained from PLN with a voltage of 220 Volts and electric current that has been measured previously, namely 0.17 Ampere, the electric power can be, namely:

- P = ?
- V = 220 V
- I = 0.17 A
- P = 220 V x 0.17 A
- P = 37.4 W

From the calculation explain, the results obtained using an electric voltage of 220V and an electric current of 0.17A are obtained 37.4W.

2. To calculate how much the electricity bill costs if used for 1 month, then use the following formula:

- Total cost = kWh used x cost/ kWh
- kWh used: Electrical power used
- Cost/ kWh: Cost rate per kWh

If the power tariff of group 1300VA is Rp1.467.28/kWh, then the cost of electricity for 1 hour of use (2 x scheduling) is:

- kWh used: 0.0374 kWh
- Cost/ kWh: Rp.1,467.28/ kWh
- 0.0374 kWh x Rp1.467.28/ kWh = Rp54.87

When the rate that must be paid on 2 scheduling times in 1 day is Rp54.87 Rupiah. If the system is made to run in 30 days with every day, there is 2 times scheduling then Rp54.87 x 30 days. Then the result obtained is Rp1.646.28 Rupiah.

4.2.5 Water Discharg

This test is to discover how much water discharge comes out based on its times. In the test will be measured how much discharge comes out of the media while scheduling process.

1. The Water Vloume Measurement Based on Watering Duration

This measurement aims to find out how much discharge and volume of water comes out, the following are the results of the test.

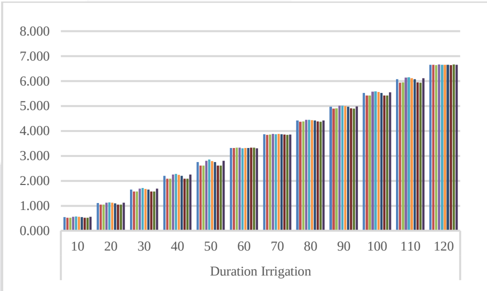

Fig.18. Water Discharge Used

Then it can be concluded that to water plants with scheduling methods takes 60 seconds with an average water volume of 3.3206 liters of water per soil media.

The next test is to find out how many liters of water are used for each scheduling or Semi-Automatic scheduling based on different watering duration times, the following are the results of the test.

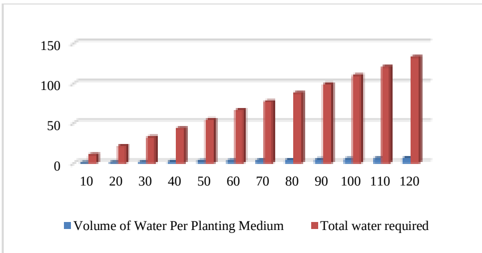

Fig.19. Volume per Planting medium

From the tests that have been done by Figure 19 the results obtained when the duration of watering for 10 seconds then the average volume obtained by each planting medium is 0.5448 L and for all planting medium recorded as much as 10,896 liters, when the duration of watering for 120 seconds then the average volume obtained by each planting medium is 6,655 L and for all planting medium requires as much as 133.1 liters.

2. The Water Volume Measurement in Each Plant

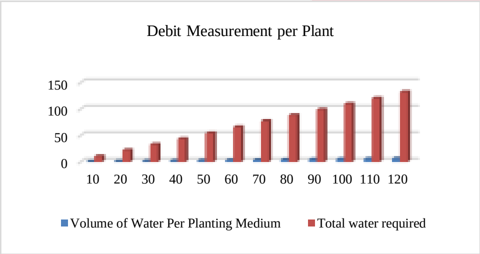

Fig.20. Debit Measurement per Plants

From the tests that have been done, seen in the figure explain for watering done for 10 seconds on the planting medium will get an average of 27.5 ML per plant and the last watering done for 120 seconds on the planting medium will get an average of 331.64 ML per plant.

3. Measurement of Water Droplets in Plants

This measurement aims to find out how much water droplets in this plant aims to find out how many water droplets will dip into a plant. Testing is done as many as 10 times to find out the number of droplets in each plant. The benchmark in this test is to use a 5mL pipette as a comparison. The following are the results of testing water droplet measurements in plants.

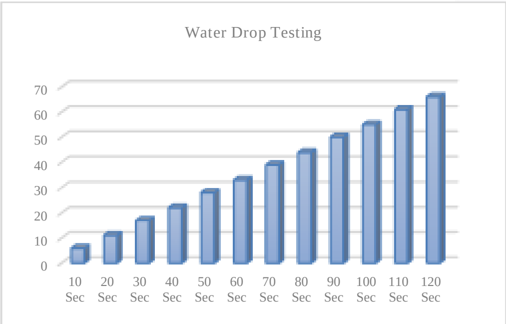

Fig.21. Water Drop Test

Based on the results of tests that have been done, figure 21 shows that the least amount when water flowed for 10 seconds will drip water to the plant on average as much as 6 times water droplets and the most testing when streamed for 120 seconds that will drip 66 times water droplets.

Conclusion

From the research that has been done in the building of Arduino Mega 2560 microcontroller for drip irrigation smart urban farming application with IoT interface, the following conclusions were obtained. Each component of the controller systems is well-attach. Irrigation systems using Arduino Mega is done optimally, the sensors, soil moisture sensors and soil pH sensors can detect effectively and perfectly. The Automatic scheduling irrigation is done optimally 2 times a day and Semi-automatic scheduling is done effectively during outside the specified hours. Water consumption for Automatic scheduling in 60 seconds is 160 mL of 33 drops each plant. The use of electricity costs per day with 2 times scheduling times is Rp54.87.

Suggestion

Based on research that has been done in the creation of Arduino Mega 2560 microcontroller for drip irrigation smart urban farming application with IoT interface, development is needed to achieve more optimal results. So, the author proposes some suggestions that are expected to help in the future, such suggestions include. iOS users can use this device and application. Add notification in the form of email or text message. Scheduling time settings can be change via smartphone to make it easier when the device at the different time zone.

References

[1] N. Ramadijanti, Mu'Arifin, and A. Basuki, "Comparison of Covid-19 Cases in Indonesia and Other Countries for Prediction Models in Indonesia Using Optimization in SEIR Epidemic Models," *7th Int. Conf. ICT Smart Soc. AIoT Smart Soc. ICISS 2020 - Proceeding, 2020*, doi: 10.1109/ICISS50791.2020.9307543.

[2] K. Taneja and S. Bhatia, "Automatic irrigation system using Arduino UNO," *Proc. 2017 Int. Conf. Intell. Comput. Control Syst. ICICCS 2017, vol. 2018- Janua, pp. 132–135, 2017*, doi: 10.1109/ICCONS.2017.8250693.

[3] A. Burhanuddin and F. Kurniawan, "Analysis of the Spread of COVID-19 in Local Areas in Indonesia," *3rd 2021 East Indones. Conf. Comput. Inf. Technol. EIConCIT 2021, pp. 36–40, 2021*, doi: 10.1109/EIConCIT50028.2021.9431906.

[4] Dhiraj Sunehra, M. Srinidhi. 2020. Implementation of Smart Urban Farming using Raspberry Pi, Arduino and Node-RED Platform. Institute of Electrical and Electronics Engineers

[5] Muhammad Ayaz, Mohammad Ammad-Uddin, Zubair Sharif, Ali Mansour, El-Hadi M. Aggoune. 2019. Internet of Things (IoT) Based Smart Agriculture: Toward Making the Fields Talk. Institute of Electrical and Electronics Engineers

[6] Lova Raju K., V. Vijayaraghavan. 2020. IoT and Cloud hinged Smart Irrigation System for Urban and Rural Farmers employing MQTT Protocol. Institute of Electrical and Electronics Engineers

[7] Aris Munandar, Hanif Fakhrurroja, Irfan F. A. Anto, Rian Putra Pratama, Joni Winaryo

Wibowo, Taufik Ibnu Salim, Muhammad Ilham Rizqyawan. 2018. Design and development of an IoT based smart hydroponic system. Institute of Electrical and Electronics Engineers

[8] Narayut Putjaika, Sasimanee Phusae, Anupong Chen-Im, Phond Phunchongharn, Khajonpong Akkarajitsakul. 2016. A Control System in an intelligent farming by using arduino technology. Institute of Electrical and Electronics Engineers.

[9] Ankita Patil, Mayur Beldar, Akshay Naik, Sachin Deshpande. 2016. Smart farming using Arduino and data mining. Institute of Electrical and Electronics Engineers

[10] Priyanka Padalalu, Sonal Mahajan, Kartikee Dabir, Sushmita Mitkar, Deepali Javale. 2017. Smart water dripping system for agriculture/farming. Institute of Electrical and Electronics Engineers

[11] M. Rohith, R. Sainivedhana, N. Sabiyath Fatima. 2021. IoT Enabled Smart Farming and Irrigation System. Institute of Electrical and Electronics Engineers

[12] Atharv Tendolkar, S. Ramya. 2020. CareBro (Personal Farm Asisstant): An IoT based Smart Agriculture with Edge Computing. Institute of Electrical and Electronics Engineers

[13] Pushkar Singh, Sanghamitra Saikia. 2016. Arduino based smart irrigation using water flow sensor, soil moisture sensor, temperature sensor and ESP8266 WiFi module. Institute of Electrical and Electronics Engineers

[14] Punya Prabha V., Sarala S. M.. Sharmila Suttur C. 2020. Robust Smart Irrigation System using Hydroponic Farming based on Data Science and IoT. Institute of Electrical and Electronics Engineers

[15] Mahi Teja Talluri, S. S. Arya, Aman Tripathi, V. Karthikeyan. 2020. IoT based Multipurpose Uniform Water Showering Mechanism for Urban Agriculture. Institute of Electrical and Electronics Engineers

[16] R. R. Thirrunavukkarasu, T. Meeradevi, S. Ganesh Prabhu, J. Arunachalam, P. Manoj Kumar, R. Prasath. 2021. Smart Irrigation and Crop Protection Using Arduino. Institute of Electrical and Electronics Engineers

[17] Bhargav Narayanavaram, E. Manoj Kumar Reddy, M. R. Rashmi. 2020. Arduino based Automation of Agriculture A Step towards Monernization of Agriculture. Institute of Electrical and Electronics Engineers.