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AUTOMATION SYSTEM HYDROPONIC USING SMART SOLAR POWER PLANT UNIT

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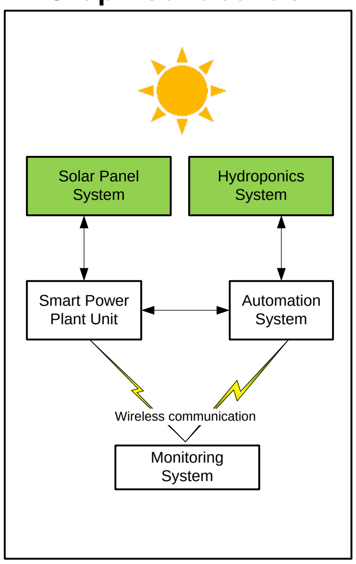
Graphical abstract



Abstract

Automation system hydroponic is one of the farming solution. There are several problems in hydroponic that can be divided into two parts. First part is the hydroponic system. The system needs to control and monitor temperature, pH and distribution of water. Second part is the power supply, generally it run from conventional electrical energy and it should continue to run all the time. Electrical energy needs is increasing from time to time. In this research, there are two possible solutions to solve the problem. The first possible solution is the automation for hydroponics system that would measure and control temperature, pH and water level in water tank. The second possible solution is smart solar power plant unit which function as primary power supply and will shift to conventional electrical energy if there is no adequate energy to run the automation for hydroponics system. The smart solar power plant unit monitor the intensity of light, voltage and electrical current between battery and DC to AC converter and the voltage that produced from solar panel. The value of temperature, pH and water level in water tank, intensity of light, electrical current and voltage will be sent to a server by wireless communication. The result of this research is a prototype of automation system hydroponic using smart solar power plant that can monitor and control pH, temperature, water level, intensity of light, electrical current and voltage.

Key words: Automation system; wireless monitoring system; hydroponic; solar panel

1.0 INTRODUCTION

The current resurgence of interest in the use of renewable energy is driven by the need to reduce the high environmental impact of fossil-based energy systemsand food safety in agricultural production systems[1]. Monitoring and Control is a key enabling technology for the deployment of renewable energy systems in agricultural production system. One of monitoring and controlling system in agricultural production system is greenhouse food production that often termed controlled environment agriculture (CEA) which usually accompanies hydroponics.[2]

Hydroponics is a technology for growing plants in nutrient solutions (water and fertilizers)with or without the use of an artificial medium (for example: sand, gravel, vermiculite, rock wool, peat moss, coir, sawdust) to provide mechanical support.Several studies have shown that hydroponics has basic requirements of hydroponics, there aregrowing medium, mineral nutrients,nutrient solution, temperature, water, light and air as shown in table 1[3].

Due to the high energy demands,improvedenergy efficiency research forhydroponiccan be found on [4]. One possible way to make commercial hydroponics amore sustainable and suitable alternative would be to relocate the greenhouse to an area where there arecheap and renewable sources of energy, such as solar, geothermal or wind power.

In this research,a prototype of automation for hydroponics system using solar power as renewable energy source is proposed. In this prototype, several parameters are measured to control the hydroponics system and solar power energy. The parameters that is measured for control and monitoring the hydroponics system are temperature, light intensity, nutrient solution. For the solar power energy, the parameters that is measured for control and monitoring are voltage and current from the solar panel system.

Table1 Basic requirement of Hydroponics [3]

No.	Parameter	Common Value
1.	Growing Medium	Coco coir fiber, Rockwool, Perlite, Vermiculite, LECA, Expanded clay, Crushed granite, Sand, Scoria, Gravel
2.	Mineral Nutrients	17 Elements
3.	Nutrient Solution	The E.C. (electrical conductivity) value 2.5, the pH value 5.5 – 6.5.
4.	Temperature	High temparature tend to accelerate the growth, generally the temperature is 22°C-28°C
5.	Wind	Higher wind tend to evaporate water
6.	Water	Should have conductivity less than 500 uS/cm, or a total salt concentration less than 350 ppm.
7.	Light	Areas that already get sunlight will need fewer hydroponic lights than a hydroponic garden grown in a fully enclosed room.

2.0 GENERAL CONCEPT OF THE SYSTEM

In this proposed system consists of 3 parts, namely: Automation for Hydroponic System, Smart Solar Power Plant Unit and Monitoring System. The general concept of the system can be seen in figure 1.

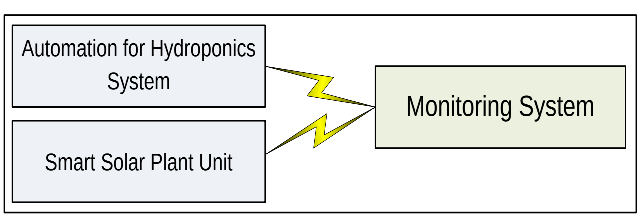


Figure 1 General concept of the proposed system

2.1 Automationfor Hydroponic System

Automation for Hydroponic System, based on figure 2, consists ofSensors, microcontroller, actuators and communication module, which monitor and control several parameters on hydroponics system : Temperatur, water pH, light intensity and water level on water tank. The sensors that was used in this research are LM35 (temparature sensor), pH meter (pH sensor), LDR (light intensity sensor) and Ultrasonic Sensor (water level sensor). Microcontroller that was used in this research is Atmega 328 with 32K Bytes In-System Self-Programmable Flash progam memory [5]. This microcontroler is programmed using Arduino IDE. On the actuator, there are three relay, that activate Water Pump, Peltier and Led Grow Light, Buzzer and LCD Display. Peltier module, which known as thermoelectric module, is an electrical module, which produces atemperature difference with current flow. The emergence of thetemperature difference is based on the Peltier effect designatedafter Jean Peltier. The thermoelectric module is a heat pump andhas the same function as a refrigerator[6]. LED Grow Light, which commonly used blue LED (with wavelength 380-480 nm) and red LED (with wavelength 630-730 nm), with could provide an alternative lighting source for hydroponically grown miniature lettuce[7]. In communication module, in this research used APC 220 433 MHz module. This module function as transmitter an receiver to send and receive information and control signal.

This automation for hydroponics system function is to detect parameters and perfom an action to control the condition within specified parameter.

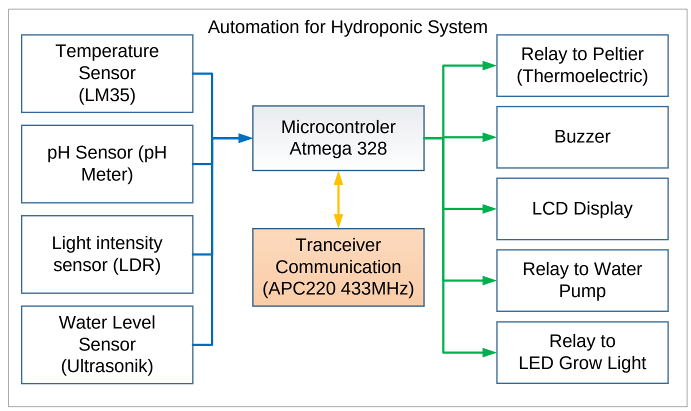


Figure 2 Block diagram of the automation system

2.2 Smart Solar Power Plant Unit

Smart Solar Power Plant unit, based on figure 3, consists ofSolar Panel Set, Sensor, actuators and communication module, which monitor and control two parameters on Smart Solar Power system : Current and voltage between Battery and Inverter DC to AC and voltage between solar panel and solar charge controller.

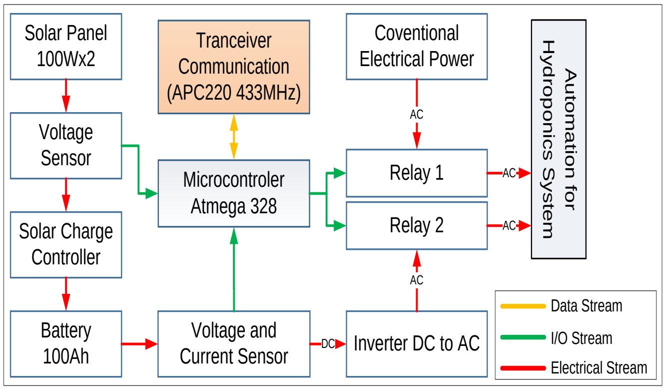


Figure 3 Block diagram of Smart Solar Power Plant Unit

The sensors that was used in this research are voltage and current sensor. The type of voltage and current sensor is voltage divider sensor and ACS712 current sensor[8].The type of microcontroller is Atmega 328 with 32K Bytes In-System Self-Programmable Flash progam memory and programmed using Arduino IDE. On the actuator, there are two relay, that activate electrical current fromConventional Electrical Power and electrical current from inverter DC to AC. In communication module, this system used APC 220 433 MHz module. This module function as transmitter an receiver to send and receive information and control signal.

This Smart Solar Power Plant Unit function is to detect voltage and current stream and perfom an action to switch power between solar panel and conventional electrical power.

2.3 Monitoring System

Monitoring System, based on figure 4, consists ofMonitor, which is used to display information from Automation for Hydroponic System and Smart Solar Power Unit, Raspberry Pi Server, that function as a server that collect data and display data to monitor, and communication module, which send control signal and receive data from Smart Solar Power Unit and Automation for Hydroponics System. Every data which received from Hydroponics System and Power Unit is then processed into graphical display using GAMBAS application version 3.1.1.

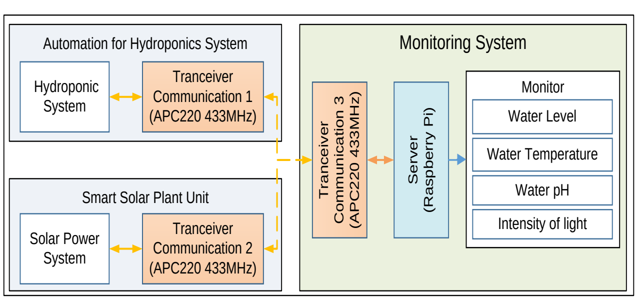


Figure 4 Block diagram of the Monitoring System

2.4 Smart Solar Power Plant Unit Flow Chart

After the system is configured accordance to the proposed concept,figure 5 shows the flowchart used for the software of Smart Solar Plant Unit. The state of using conventional electrical power or solar power can be varied depends on the condition of the battery.

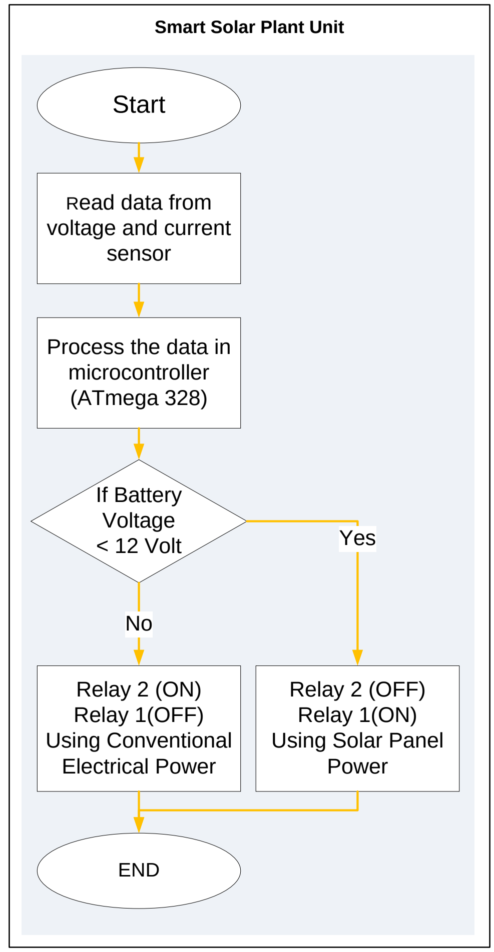


Figure 5 Flow Chart of the Smart Solar Plant Unit System

2.5 Automation for Hidroponics System Flow Chart

Figure 6 shows the flowchart that used for the software of Automation for Hydroponics System. The state of peltier, water pumps, buzzer and LED grow light depends on the condition of water and intensity of light.

2.6 Monitoring System Flow Chart

Figure 7 shows the flowchart that used for the software of Monitoring System. The server send signal 1 or 2 then in sequentially receive data from Hydroponics system and power plant unit. The data that was received on server are temperature, water level, pH water, light intensity, current and voltage.

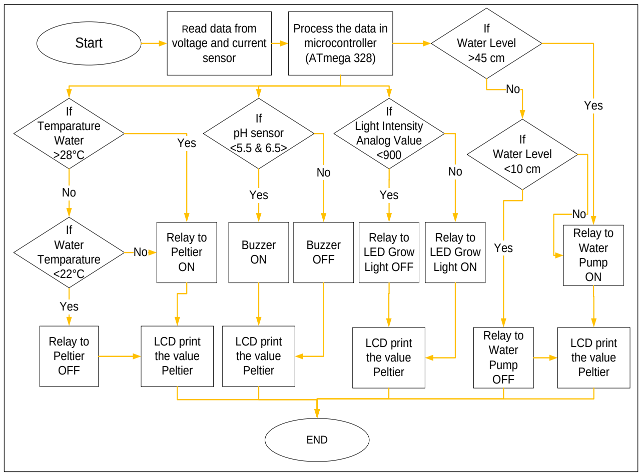


Figure 6 Flow Chart of Automation for Hydroponics System

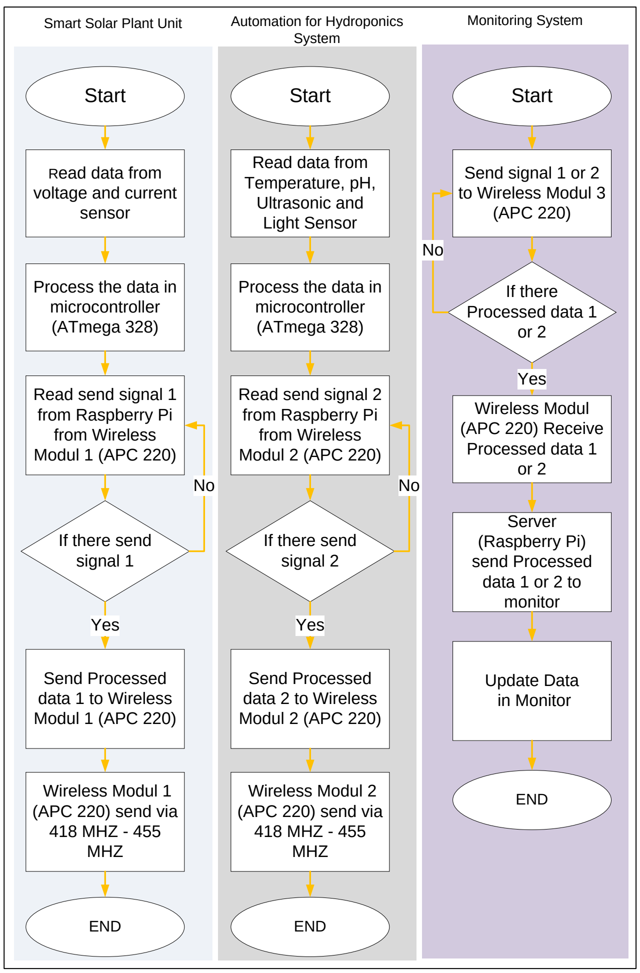


Figure 7 Blockdiagram of the Monitoring System

3.0 RESULTS AND DISCUSSION

3.1 Hardware Result

Figure 8 shows the hydroponic system with several type of hydroponics plantation. Figure 9 shows hydroponics system with Grow LED Light in On state. Figure 10 shows the automation for hydroponics system with intensity of light is been displayed in LCD Display. Figure 11 shows the smart solar panel unit with 2 solar panel 100 Watt with 100 Ah baterry. The last figure, figure12 shows water level, temperature value, analog LDR value, pH sensor value, current and voltage value to the monitor display which was processed from Raspberry Pi.

Figure 8 Hydroponic System

Figure 9 Hydroponic with Grow LED Light

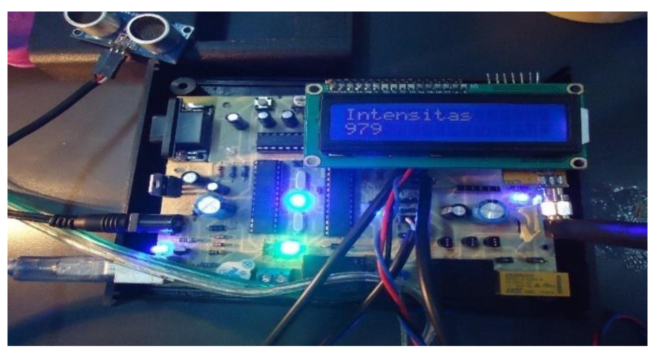


Figure 10 The automation for hydroponic system

3.2 Experimental Result

After programming the prototype, the test is conducted to test the function of the prototype. Testing parameter that will be tested are, LDR value which affect the state of Grow LED Light, LM35 value which affect the state of peltier, Ping(ultrasonic sensor) which affect the state of Pump and pH sensor that affect the state of Buzzer.

Figure 11 Smart Power Plant Unit

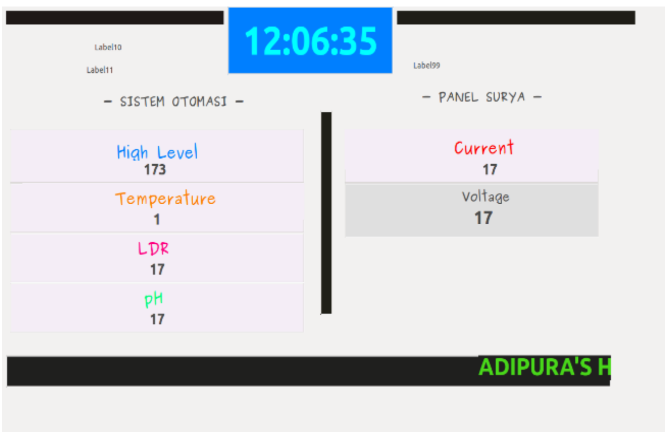


Figure 12 Monitoring System which shown in monitor display

The duration for conducting the test is 15 minutes in the morning, noon and afternoon. The data is taken every 3 minutes. This test is done to check whether the system is run according to design. The result of the test can be seen in table 2, 3 and 4.

Table2 Testing System at 9:00 to 9:15 pm

LDR (Analog Value)	Grow LED	LM35 (ºC)	Peltier	Ping (cm)	Pump	pH	Buzzer
267	Off	25.0	Off	15	Off	6.4	Off
357	Off	27.1	Off	26	Off	6.4	Off
357	Off	29.6	On	32	On	6.4	Off
340	Off	31.0	On	42	Off	7.1	Off
340	Off	25.1	On	49	On	6.4	Off

Table 3 Testing System at 12:48 to 13:03 pm

LDR (Analog Value)	Grow LED	LM35 (ºC)	Peltier	Ping (cm)	Pump	pH	Buzzer
388	Off	27.3	Off	40	off	6.4	Off
439	Off	31.2	On	49	On	7.1	On
439	Off	25.2	On	29	On	7.5	On
443	Off	22.0	On	17	On	7.5	On
393	Off	21.5	Off	9	Off	6.4	Off

Table 4 Testing System at 4:30 to 4:45 pm

LDR (Analog Value)	Grow LED	LM35 (ºC)	Peltier	Ping (cm)	Pump	pH	Buzzer
856	On	28.0	On	5	Off	6.4	Off
760	On	28.1	On	16	Off	6.4	Off
880	On	23.1	On	28	Off	6.4	Off
880	On	24.4	On	39	Off	6.4	Off
889	On	22.1	On	48	On	6.4	Off

3.3 Discussion and Analysis

From the testing table 2, 3 and 4, we give some analysis:

1. For the light intensity, the average of light intensity is 535.2. The system is ran accordance to the design, where the Grow LED light will turn to ON state if the analog value of the LDR is more than 900.
2. The average water temperature is 25.46°C. The system ran accordance to the design, where the Peltier will turn to ON state if the water temperature more than 28°C and will still in ON state until the water temperature below 22°C.
3. The water level sensor is ran accordance to the design, which run the water pump when distance, which measured by ping (ultrasonic) sensor, is more than 45 cm. The water pump will still in ON state until the distance is less than 10 cm.
4. The level of acidity (pH) in the water reservoir is on level 6.43, which is in good pH value for plant growth.

4.0 CONCLUSION

A prototype of automation for hydroponics system with smart solar panel unit is proposed. In this prototype, the system ran accordance the prototype design. The communication module work as designed. The data that send from the prototype can be received in the Raspberry Pi Server which showed the information in to display monitor. Currently, the prototype is being improved to control pH nutrient mineral and nutrient solution automatically.

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