

Control System Design for Water Pump Activation in PLC-based Smart Hydroponic Design

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Abstract—Food security is one of the concerns of the country's government, and one of the independent efforts made by the community to meet and achieve food needs on a domestic scale in their respective households is through the hydroponic cultivation of vegetables. Hydroponics works by using water instead of soil as a growing medium; however, using water as a planting medium requires special treatment. Thus, the plants can grow optimally. A water regulation process is needed to ensure that the air content in the water used as a hydroponic growing medium is properly available. Water regulation in the hydroponic system uses regulation of the activation of the water pump motor so that water can be regulated and electrical energy efficiency can still be achieved. This study aims to design and test a PLC-based automation system for the purposes of setting the activation of a water pump in a hydroponic system based on the sunlight conditions in the hydroponic installation being built. By using a light sensor (LDR) to measure the intensity of sunlight in the hydroponic system being built, the activation of the pump motor can be controlled through the use of a PLC device that processes the information obtained from the sensor used. The results of the tests carried out provide information that the designed system has proven effective for use in hydroponic systems with pump water regulation time from 08:00 AM to 04:00 PM.

Keywords: *hydroponic, LDR sensor, PLC, water pump activation, water regulation*

I. INTRODUCTION

Food security (especially from the vegetable side) is one of the national issues that is one of the concerns to the country's government, including the Indonesian government, but one of the factors that is the biggest issue of food security is the availability of land for growing food crops [1].

One of the independent efforts made by the community on their awareness to meet and achieve food needs on a domestic scale in their respective households is through the hydroponic method for cultivation of food crops because hydroponics is a method of cultivating plants that do not require large areas of land and is easy to maintain, thus hydroponic is very suitable for development on a household scale, especially in urban areas that continue to grow [2].

Types of fruits and vegetables that can be cultivated using the hydroponic method are short-lived plants, such as mustard greens, lettuce, tomatoes, spinach, cucumbers, cherry tomatoes, and bitter melon. Those plants are plants that are often consumed on a household scale, so they are suitable if cultivated independently in the household [3].

Hydroponics works by using water as a growing medium instead of using soil [3], however, the use of water as a planting medium requires some special treatment thus the plants can grow optimally even though they use water as a planting medium [4]. In the soil, there are certain nutrients and minerals needed by plants and these

are not found in water, thus it is necessary to manually add nutrients and minerals to the water used as a planting medium. In addition, one of the important elements that must be present in the planting medium is air, in the use of soil as a planting medium the availability of air is obtained through the manual process of loosening the soil which is carried out periodically [5].

To ensure that the air content in the water used as a hydroponic growing medium is properly available, a water regulation process is needed [3]. There are several methods of water regulation in a hydroponic system to ensure that the air content is always available in the water used as the planting medium [4], some of those are (1) drip system; (2) flow system; (3) nutrient film technique; and (4) aeroponic system.

In that water regulation technique, it is necessary to use an electric water pump to help the water flow in the hydroponic system. However, one thing that needs to be known is the efficiency of the electrical energy used to operate the irrigation system. Water regulation in a hydroponic system does not need to be carried out endlessly, regulation only needs to be carried out in hot sun conditions where the evaporation process occurs optimally [1]. Thus, to increase electrical energy efficiency while maintaining air regulation in the water as the planting medium, a control system is needed that can regulate the activation of the water pump so that it is only active when the sun is hot.

A Programmable Logic Controller or PLC is a control device that has the reliability to be able to perform

monotonous control over a long period [6], this is a distinct advantage when compared to other control devices (such as microcontrollers, electronic-analog controllers, or mini computers). In addition, PLC can receive analog signal input directly from the sensor used without using an external analog-to-digital (ADC) converter circuit [7]. However, not all PLC devices have an internal ADC feature, thus, in some cases an external ADC circuit and signal conditioning circuit are needed before the sensor signal can be processed by the PLC device [8].

As has been mentioned the PLC device is a control device that can work monotonously for a long time [6], thus the use of PLC devices in the design of smart hydroponic systems is very possible to use. In the early stages of developing and designing a smart hydroponic system, the fundamental process that needs to be controlled is the process of water regulation in the hydroponic system. Thus, the main objective of the research conducted in this paper is to design a control system for activating a water pump to regulate water regulation in a hydroponic system using a PLC device.

Previous research proposed a hydroponic irrigation automation design based on environmental temperature [2], where there is still a gap for measurement errors because conditions without sunlight may occur but the environmental temperature increases, while the factors that influence evaporation and the effectiveness of hydroponic plants are not only temperature factors. but also from the light factor. So this research aims to design an automated hydroponic irrigation system based on the sunlight intensity factor, which can later be combined with a temperature sensor. In addition, compared to temperature sensors which are easily interrupted due to humidity, light sensors have a better response because they are not interrupted due to changes in temperature or humidity, so they have better performance.

II. LITERATURE REVIEW

Theories used and referred to in this study include but are not limited to theories about the management of water circulation in hydroponic systems, signal processing techniques, interfacing techniques, and control circuit design techniques in a PLC.

A. Water Circulation in Hydroponics

Water circulation and regulation in a hydroponic system are divided into several types when viewed from an irrigation technique perspective [4], however, from all of those irrigation techniques there is one thing in common in all of those irrigation techniques: regulation of water flow, when water should flow and when water should be no need to flow.

Regulating the circulation of water in a hydroponic system is fundamental and very important because it will directly affect the amount of production costs that are required in the hydroponic system [9], this is the result of

using an electric water pump which functions to regulate water circulation in the hydroponic system.

From an economic point of view in operating a hydroponic system, the main irrigation in a hydroponic system does not need to be carried out continuously throughout the day and night, ideally it only needs to be done during the hot sun conditions when evaporation occurs at its maximum [2], besides that, plant roots that are exposed to or continuously submerged in water will have the potential to rot and result in damage and death of cultivated hydroponic plants [9].

Generally, practitioners engaged in hydroponics use a timer component to turn on and turn off the water pump they use for irrigation of the hydroponic system [1][4][9], the timer is set in such a way that the pump can be active at eight in the morning when the sun rises and the pump goes off at six in the evening when the sun goes down.

To increase efficiency in terms of operational costs, practitioners usually turn off the water pump when the weather conditions are cloudy or when it rains [9] because in these conditions no evaporation occurs or it can be said that the evaporation conditions that occur are the same as those that occur at night. However, this process is still done manually because the timer that is generally used only knows the condition when the pump starts and the end time to turn off the pump, this timer does not know other times to turn off or turn on the pump based on the surrounding environment.

B. Signal Processing Techniques

There are two types of signals in their context as information for controlling devices: analog signals that have a range of various condition values and digital signals that only recognize 'yes' and 'no' conditions in them [8], [10]. The pump motor as an electrical component can be controlled for two purposes: (1) to regulate when the pump motor should be active or inactive and (2) to regulate the rotation speed.

An electric motor whose rotational speed is controlled will use information in the form of an analog signal that represents the desired speed, generally the greater the analog value given, the faster the rotation of the electric motor. Meanwhile, electric motors that are only controlled when they are active and inactive will use information in the form of digital signals that represent 'yes' or high logic conditions to run the motor and 'no' or low conditions to deactivate the motor [6].

The use of PLC to control electric motors can be used with due regard to the following conditions: (1) Will the speed be controlled or only the activation? (2) Does the PLC device used have an internal ADC facility or not? (3) Is the input device used to provide signal information in analog format or digital format? By knowing these three conditions, it can be determined how the signal processing method will be used to regulate the electric motor. To control the activation of electric motors from inactive to active or vice versa, it would be better to use control

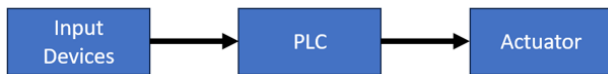


Figure 1. Signal processing block diagram without ADC



Figure 2. Signal processing block diagram with ADC

inputs in the form of digital signals that provide ‘yes’ or ‘no’ information and there are no conditions in between, as well as use the ADC feature on the PLC internally or externally no need to use. Thus, the process flow of the input signal into control information will look like the one in Figure 1.

Meanwhile, to control the rotational speed of the motor, an analog input device is needed that provides an information signal within a certain value range which will be converted into a motor rotational speed value through the use of an ADC feature that is connected to the PLC device. Thus, the process from the input signal to the motion of the electric motor as an actuator can be seen in Figure 2.

If the electric motor wants to be controlled only from the activation side but the input devices used are the devices with an output in the form of an analog signal, then the signal processing will be carried out using the technique as seen in Figure 2, with the ADC parameters used is set to the cutoff and saturation conditions only, thus the conditions are similar to the output signal from devices with digital signal output [6], [8]. From Figure 2, it can be seen that the ADC is in the same section as the PLC device, this is an indication that the ADC and the PLC device are inseparable parts, both externally and internally in the PLC system itself.

C. Interfacing Techniques

Interfacing is a technique used to connect two or more devices so that they can communicate with or are connected [10]. The interfacing technique discussed in this paper is about how to connect sensors or input devices thus they can connect to the PLC devices.

PLC devices are controller devices that generally work with a logic input of 24 Volts DC [6], while sensor devices that are used as input devices in a system generally work on TTL logic of 5 Volts DC or some sensors can be found to work on logic of 12 Volts DC [10].

Generally, when the input device has an operational voltage level that is different from the control device voltage level, a device or circuit is needed that functions as an interface to equalize the input device voltage level thus it is the same as the control device voltage level [10].

The position of the device or interface circuit is between the sensor device as the input device and the control device, an illustration of the installation can be seen in Figure 3. Interface devices that function to equalize the voltage level between input devices and control devices



Figure 3. . Interface device installation block diagram between input devices and controller devices



Figure 4. Interface device installation block diagram between controller devices and output devices

generally consist of transistor components if the equalized voltage level is at a small to medium level (5 Volt DC up to 50 Volt DC) or use a relay component if the voltage level to be equalized is at a medium to large level (50 Volt DC up to 220 Volt DC) [10].

The same thing applies if it is necessary for the system to do interfacing between the control device and the output device, this case will be encountered if the output voltage value of the control device is different from the voltage value required by the output device (generally the actuator) to operate. Unlike what is illustrated in Figure 3, in the interfacing condition between the control device and the output device, the control device will be on the input side as can be seen in Figure 4.

However, there are no special restrictions that require the use of transistors at low voltage levels and/or the use of relays at high voltage levels, these two components can be used according to the needs of the design being developed, generally relay components have better durability when compared to transistor components. However, what needs to be considered is the specification of the transistor used, it is necessary to ensure that the transistor used has working voltage range values that match the expected interfacial voltage.

III. DESIGN AND METHODS

The research conducted in this paper is the initial design and simulation stages; several basic experiments were also carried out to prove the accuracy of the simulation results that had been carried out. The research aims to design an automatic water pump activation system for DFT and NFT hydroponic systems, because in both of these hydroponic systems, there is standing water that provides nutrients to plant roots, thus the activation of the water pump as a function of water flow regulation is not needed to turn on every time [11-12].

The DFT (Deep Flow Technique) hydroponic system is a method of growing plants without soil. In a DFT system, plants are suspended in a shallow, flowing nutrient solution that provides them with essential minerals and water. The plants’ roots are submerged in the nutrient-rich water, and a thin film of water continuously flows over the roots. This constant flow of oxygenated water ensures that the plants receive adequate nutrients and oxygen while allowing for efficient absorption.

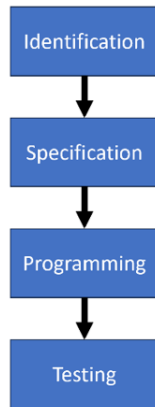


Figure 5. PLC control design work process

The NFT (Nutrient Film Technique) hydroponic system is a method of growing plants without soil. In an NFT system, a shallow, sloping trough or channel is used to continuously circulate a thin film of nutrient-rich water over the plant roots. The plants are typically grown in small pots or cups with their roots exposed to the flowing nutrient solution. This ensures that the roots receive a constant supply of water, oxygen, and essential nutrients.

A. PLC Control Design

The first step in designing control on a PLC device is to determine the type and specification of PLC used to obtain maximum efficiency [6-8]. The use of a PLC device in the system must first be identified whether to use a compact type PLC device or a modular type PLC device, this decision is taken by taking into account the needs of the system, whether it tends to expand or not.

The features and number of I/O that exist on a PLC device also need to be considered as an initial step in the control design process on a PLC device, this is related to cost efficiency in the developed system because the tendency for procurement costs for a PLC device will increase according to the amount of I/O and how many features offered [7].

After knowing the type and specifications of the PLC device to be used, the next step that needs to be done in the PLC control design stage is to create a logic program that will be embedded in the PLC as efficiently as possible so that memory allocation can be maximized.

Then, the final process in the PLC control design is testing, by simulation or directly on the system. The decision to carry out simulation or direct testing can be determined by the urgency of developing the designed system. Thus, the stages involved in the PLC control design process can be illustrated as shown in Figure 5.

B. Sensor Design

Since the system designed in this study aims to regulate the activation of the water pump based on the intensity of sunlight which is directly proportional to the level of evaporation that occurs, the main sensor used in this study is a light sensor that adjusts the resistance value or is

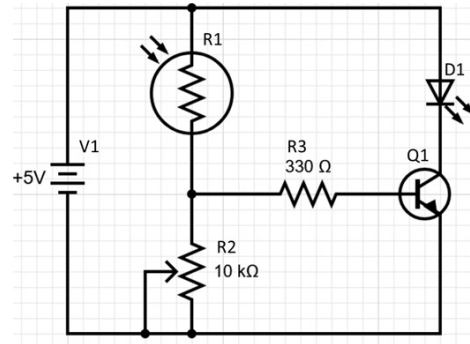


Figure 6. Design of sensor circuit.

known as a light dependent resistor (LDR).

The sensor circuit system that is built in this study uses LDR components as the main sensor, potentiometers, resistors, and an NPN-type transistor as can be seen in Figure 6. The components used in Figure 6 use a direct voltage power supply with a voltage value of 5 Volt DC (V1), an LDR (R1), a potentiometer with a maximum value of 10kΩ (R2), a 1/4 watt resistor with a resistance value of 330Ω as base current resistor (R3), an NPN transistor of the BC548 type which functions as an electrical switch for the sensor circuit (Q1), and an LED which functions as an indicator for activation of the sensor circuit (D1).

The sensor circuit in Figure 6 works with the principle of activation based on the light intensity hitting the LDR component, and the circuit is designed to provide a high logic if there is a high enough light intensity that hits the surface of the LDR component. The PLC device uses this high logic as an input signal to be processed as an instruction that controls the activation of the water pump motor.

The use of a potentiometer in the sensor circuit in Figure 6 is intended as a calibrator component that regulates the activation of the transistor component as a switch activated by the LDR component. The activation of the transistor in the sensor circuit in Figure 6 works with the principle of transistor cut-off and saturation region, which uses the voltage value from the voltage divider that occurs between LDR components and potentiometer components obtained through the equation:

$$V_{out} = \frac{R_p}{R_p + R_L} V_{in} \quad (1)$$

The V_{out} value is the voltage value that is used to activate the transistor which functions as a switch, the V_{out} value is obtained from the voltage divider calculation as in Equation (1), and the R_p value is the resistance value that exists on the potentiometer component, while the R_L value is the resistance value that exists in the LDR component, the value of V_{in} is the value of the power supply voltage used in the sensor circuit.

The transistor component in Figure 6 uses a TIP 31 (NPN) transistor, while the use of an LED serves as an indicator that indicates whether the sensor circuit is active or not.

C. Sensor and PLC Interface Design

The PLC device used in this study is the Omron brand PLC with the CP1E type which works with an input logic voltage of 24 Volts DC, thus, an interface is needed to make sure that the sensor reading results can be processed by the PLC device, this is because the sensor circuit that is proposed in Figure 6 uses a working voltage level of 5 Volts DC while the PLC itself works using a voltage level of 24 Volts DC.

Since the automatic control system proposed in this study will work continuously and for a long period, the selection of interface components to be used must be components that have good enough durability when used continuously and for long periods. Transistor as one of the interface components has advantages in terms of the speed of its transition from active to inactive conditions and vice versa, but the weakness of using transistors is their durability which is not good enough when used in continuous systems for long periods. Relay is also one of the interface components that can change from active to inactive or vice versa in a short time but slower than the transistor transition response, it's just that relays have advantages in terms of durability in continuous use for

long periods.

The components used in Figure 7 use a direct voltage power supply with a voltage value of 5 Volt DC (V1), an LDR (R1), a potentiometer with a maximum value of 10k Ω (R2), a 1/4 watt resistor with a resistance value of 330 Ω as base current resistor (R3), an NPN transistor of the BC548 type which functions as an electrical switch for the sensor circuit (Q1), and an 5 Volts Relay which functions as an interface for activation of the sensor circuit (K1). It promotes the use of relays as interface components that connect sensor circuits with PLC devices, as can be seen in Figure 7.

The use of relays was chosen in this study because of their good durability for long-term use since the automation system designed in this study will work continuously for a long time. In addition, in this study there is no need for a very fast activation time transition between pump activation and pump deactivation, thus the transition response time owned by the relay is sufficient to deal with the interface problem.

The working principle of the circuit proposed in Figure 7 is to activate the relay mechanism through the sensor circuit, thus the activation of the sensor is also the activation of the relay. Activation of the relay requires a voltage of 5 Volts DC which is supplied to the relay coil, while the voltage used for the interface is connected to the common pin on the relay, in this study the interface voltage used is 24 Volts DC which is by the needs of the input logic operation on the device PLC Omron CP1E.

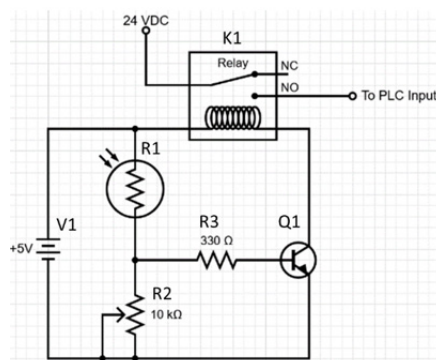


Figure 7. Relay as an interface for sensor circuit

D. PLC Control Design

The design of the control system in this study is to use a PLC device that is connected to five sensor outputs which will be installed at several points in the hydroponic system that will be made.

The use of five sensors in the control system in this study aims to increase the accuracy of detecting light

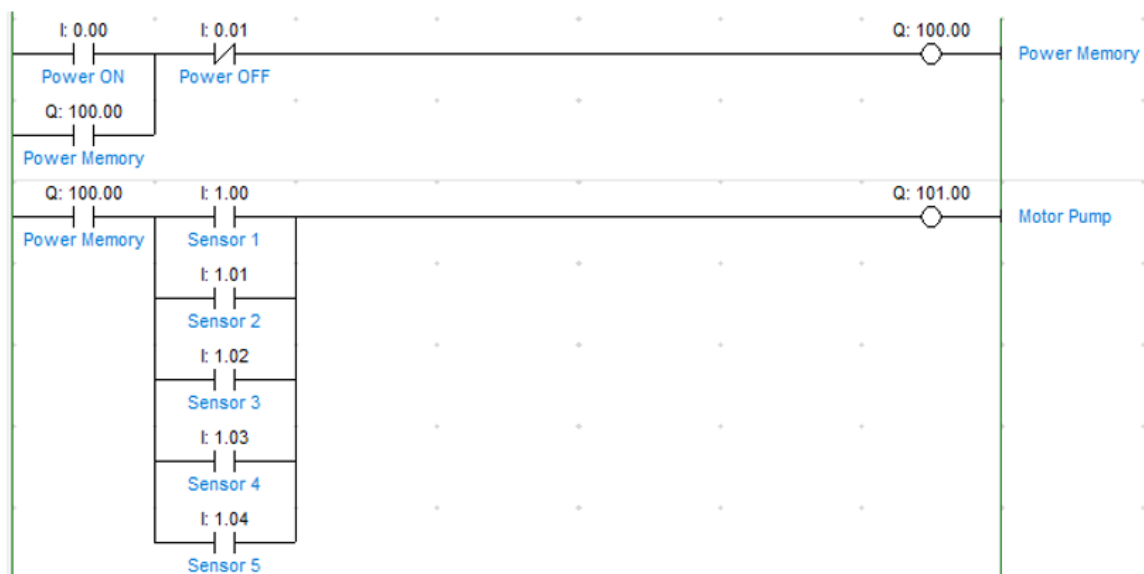


Figure 8. PLC ladder diagram for motor pump activation

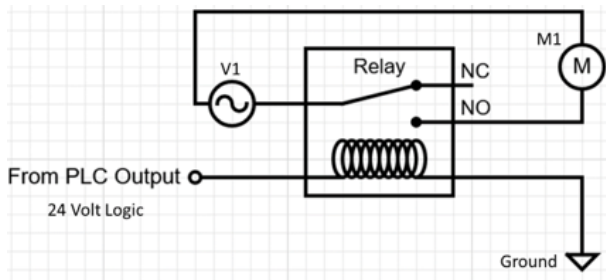


Figure 9. Relay as interface for actuator

conditions in the environment around the hydroponic system to be made, this is also to prevent malfunctions in one of the sensors so that the results of the detection of light conditions are still relatively accurate.

Since the control system in this study uses five sensors and the requirement condition for the pump motor to be activated is that one or more sensors detect the intensity of sunlight, thus the control program used on the PLC device (ladder diagram) is built using the OR logic gate principle which allows obtaining high logic at the output of the PLC device if one or more of the inputs given has a high logic value, the ladder diagram used in this study can be seen in Figure 8.

The 100.00 coil in Figure 8 functions as Power Memory which is used as feedback to activate the self-holding circuit in Figure 8. When the 100.00 coil is active, the 100.00 contact will also be active and channel energy to continue activating the 100.00 coil even though the 0.00 contact is no longer activated, this is the reason why the coil whose address is 100.00 is called power memory, because it stores power to continue activating the existing control circuit.

As a manual control feature when an automation system is not needed, the ladder diagram that is built is given an interlock circuit feature that allows activation of the control system thus it can be controlled manually when it should be used and when it should not be used.

E. PLC and Actuator Interface Design

Similar to the interface problem between the sensor circuit and the PLC device, the same case is also found in the interface between the PLC device and the actuator to be used, a water pump motor that works using an alternating voltage of 220 Volts AC.

The relay used in Figure 9 is a relay that works at a voltage of 24 Volt DC, the main coil of the relay is connected to the phase flow from an alternating voltage source of 220 Volt AC (V1), while the neutral flow from the voltage source V1 is connected to the pump motor coil (M1). The other coil in the pump motor is connected to the NO contact of the relay used.

The use of an interface between the PLC device and the actuator is not necessary if the working voltage of the actuator used has the same voltage level as the output logic voltage of the PLC device used if the voltage level between the two devices is not the same (larger, smaller, or different types voltage) then the interface circuit needs to be used.

Table 1. Sensor condition experiment

No	Sunlight Condition	Time	Sensor Condition
1	Dawn	06:00 AM	Inactive
2	The sun is shining moderately	08:00 AM	Active
3	The sun is shining brightly	01:00 PM	Active
4	The sun is shining moderately	04:00 PM	Active
5	Dusk	06:00 PM	Inactive

Table 2. LDR resistance value measurement

No	Time	Sensor Condition	Resistance Value in LDR
1	06:00 AM	Inactive	1.2M Ω
2	08:00 AM	Active	2.8K Ω
3	01:00 PM	Active	530 Ω
4	04:00 PM	Active	2.3K Ω
5	06:00 PM	Inactive	1.8M Ω

Figure 9 is the interface used in this study to connect the PLC device with a water pump as the main actuator which is driven using an alternating voltage of 220 Volts AC. The concept used is the same as the interface concept between the sensor circuit and the PLC device, relay activation is controlled via the PLC output and the load controlled by the relay is an alternating voltage that will be connected to the water pump motor.

Although in some PLC devices, it is possible to directly use alternating voltage at the output terminal, the use of interfaces on the output side in this study aims to increase the safety factor of the PLC device, thus if a system failure occurs on the actuator side it will not result in damage to the PLC device, the damage will only occur in the relay component.

IV. RESULTS AND DISCUSSION

The discussion in this paper discusses the test results and the design of a suitable control system to control water pump activation in a smart hydroponic system.

A. Sensor and Sensor Interface

Testing on the sensor and sensor interface section aims to measure and find out the performance of the sensor circuit that has been made and whether it can function properly as expected. The first test is to test the performance of the sensor circuit that has been made, whether is it able to be active or inactive according to the intensity of sunlight around the hydroponic system to be made. From the initial tests that have been carried out, it is known that the sensor circuit will be active when the sun is partially shining and shining brightly, namely from 08:00 AM to 4:00 PM as shown in the experimental results in Table 1.

Table 3. Voltage in transistor base

No	Resistance Value in LDR	Resistance Values in Potentiometer	Base Voltage
1	1.2M Ω	8600 Ω	0.03 Volt
2	2.8K Ω	8600 Ω	3.77 Volt
3	530 Ω	8600 Ω	4.70 Volt
4	2.3K Ω	8600 Ω	3.94 Volt
5	1.8M Ω	8600 Ω	0.02 Volt

The time when the sensor circuit works is the time when evaporation often occurs in the water used in the hydroponic system, thus the active time of the sensor is by the expected goals.

The second test carried out is measuring the resistance value generated by the LDR component when the sensor circuit is active and inactive, including measuring the value of the voltage flowing to the transistor thus the transistor is active in the sensor circuit.

From the experiments that have been carried out to measure the resistance of the LDR component, based on the measurement results in Table 2, it is known that when the sensor circuit is inactive, the resistance value of the LDR component is in the range of millions of ohms, and when the sensor circuit is active then the resistance value of the LDR component is in the range of hundreds to thousands of ohms.

To activate the transistor component that works as a switch in the sensor circuit that has been made, the working voltage on the transistor base must be at least 3.3 Volts DC which is sourced from the result of the voltage division between the LDR component and the potentiometer component using Equation (1), the result of the measurement the voltage flowing at the base of the transistor can be seen in Table 3.

In the sensor circuit that has been built, a source voltage of 5 Volts DC is used and the resistance value on the potentiometer component is set and calibrated at a value of 8600 Ω , the calculation results calculate the voltage flowing on the transistor base show that when the transistor is active the value of the voltage flowing in the transistor base is at a value greater than 3.3 Volt DC, whereas when the transistor is not active the value of the voltage flowing at the base of the transistor is at a value much smaller than 3.3 Volt DC. The results of the experiments and calculations that have been carried out conclude that the sensor circuit proposed in this study can function properly and as expected.

The existing system continues to be turned on when the sensor is in active condition, namely from 08:00 AM to 06:00 PM. Over the entire activation time, the average resistance value of the LDR component is 1900 Ω , which will provide a base voltage of 4.09 Volt DC which is suitable for activating the transistor which functions as a switch in the sensor circuit.

Likewise in testing the sensor circuit interface, relay activation can be controlled properly through transistor

activation, the relay is activated by flowing ground current from the transistor to the relay coil which is not connected to a 5 Volt DC voltage. Thus, the interface circuit for the sensor circuit to the PLC device that is proposed in this study is proven to be usable and functioning as expected.

Based on the experimental results in Table 2, it is known that the water pump works effectively for approximately 9 hours a day, compared to a regular switch system which is generally turned on continuously for 24 hours. In this experiment a conventional water pump is used which is commonly used in hydroponic systems, a pump with a power of 80 watts. If the basic electricity tariff for households in Indonesia with 2200VA power is IDR 760/kWh, then the conventional system costs IDR 1500, whereas the proposed system only costs IDR 550, a savings of 63.3%.

B. PLC Control Program

The control program (ladder diagram) in Figure 8 was tested by simulation and directly on the PLC device used in this study (Omron CP1E), the results of tests carried out by simulation and direct experiment showed the same results, the program worked optimally as expected.

The first test is carried out with the condition that all sensors used are in active condition, thus the Sensor 1 to Sensor 5 switches in the ladder diagram are in the active position and cause the output contacts for the pump motor to also become active, the same test continues to be carried out by alternately setting the sensor in an inactive condition, the result obtained is that the pump motor remains active even though there is only one active sensor. The pump motor will not activate when none of the sensors is active or when the Power Off switch is activated even though all sensors are active.

Thus, the results of the experiments that have been carried out prove that the control system design proposed in this study can regulate pump activation based on sunlight conditions detected by a series of sensors, and when a malfunction occurs on one of the sensors, the system will continue to operate by using information from the remaining sensors.

C. Actuator and Actuator Interface

The actuator used in this study is a water pump for household scale with a power capacity of 250 watts with a suction and thrust capacity of 9 meters / 24 meters. The actuator can function properly when its activation is controlled automatically through the PLC-based control proposed in this study. The interface used also functions properly, can be controlled via the output of the PLC device and can supply an alternating voltage of 220 Volts AC to the actuator used.

The thing that becomes a concern in this test is the appearance of abnormal heat in the actuators and relays used, but during the testing process, there is no excess heat in the actuators and relays used in the system being made.

V. CONCLUSION

Based on the design, testing, and analysis processes that have been carried out, it appears that controlling the activation of the water pump in the hydroponic system can be built automatically by using a PLC as the control device and by using a series of light sensors that detect the intensity of sunlight around the hydroponic system being built. The system proposed in this study has proven to be effective in controlling the activation of the water pump; thus, it can be active from 08:00 AM to 4:00 PM in hot sun conditions without overcast throughout the day.

When cloudy conditions occur, it is hoped that the pump motor will not function because the sensor does not detect the same intensity of sunlight as when the day is sunny. When conditions without sunlight occur, the resistance value generated by the LDR component will increase drastically, high enough that the voltage generated entering the base of the transistor will be lower than 3.3 Volt DC; the transistor will not be active.

The research is the initial part of designing an intelligent control system for farming and aquaponic cultivation that can be controlled and monitored wirelessly. With the results obtained from this research, the development of the main system can be carried out well, especially in terms of power saving and acquisition of sensor data.

In the future, it is hoped that there will be further research that specifically examines the evaporation rate in hydroponic systems; thus, it is hoped that the efficiency of electrical energy from the activation of the pump motor can be increased by deactivating the pump motor in bright sun conditions. Still, the potential for evaporation to occur is quite low, and re-activating the pump motor when the potential evaporation occurs is quite high.

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