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Implementation of Soft Starter on Pumps and Agricultural Monitoring Systems with Pest Exercise Technology to Increase Agricultural Efficiency

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Abstract

The pump starting current can be multiple times higher than normal current. Besides raising the electricity bill, a very high current surge at starting can cause damage to other electronic components. This study aims to implement a soft starter that functions to reduce the electrical power required to start the pump up. To measure electrical variables while the pump is working, the PZEM-004t sensor is used as a voltage, current, and energy sensor. The sensor has been validated and has an accuracy of 99.63% for current measures and 99.87% for voltage measures. In addition, to increase the efficiency of agricultural yields, a monitoring system for soil moisture in the fields is also applied with pest control technology. The soil moisture sensor YL-69, which has been validated with an accuracy of 98.27% is used to measure soil moisture in agricultural land. Specifically, this monitoring system utilizes solar electricity, which is abundant in open areas, while the pump system still uses grid electricity. Those two systems are then integrated using an Android application. The results of this study found that the use of a soft starter can reduce current up to 20.64% with a 3A motor and 15.32% with a 1.7A motor.

I. INTRODUCTION

Pumps' starting current surge can reach between 5 to 8 times the normal current [1]. The high current can cause overheating of the pump [2], [3], [4], [5] . This can also cause damage to other equipment in the same electrical system [6]. Besides that, the uncertainty of rain also makes it difficult for farmers to activate and deactivate the pump. The solution to this problem is the application of a real-time monitoring system for the state of the rice fields [7]. Usually, humidity sensors are used for monitoring soil moisture and controlling pumps to produce an automatic irrigation system [8], [9], [10], [11], [12]. Irrigation flow should also stop when it rains with a high enough intensity. Then if the rain has stopped while the required soil moisture has not been reached, the pump shall be reactivated to meet these needs.

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As a solution to this problem, it is necessary to apply a soft starter to the pump system used for agricultural irrigation. The application of this soft starter is to reduce the starting current, so it becomes more stable. In addition, this system will be having a monitoring function on soil conditions as well as on the intensity of rainwater that falls during irrigation. The value of the sensing process will then be monitored by farmers to determine irrigation time. To increase agricultural yields, this system is equipped with light traps. The function of the light trap itself is to catch pests that have the potential to damage plants. The method applied to the designed light trap is the use of LED lights and water. With the application of this system, it is expected to increase the efficiency of the irrigation process so that farmers can cut spending on irrigation.

II. MATERIALS AND METHODS

A. Soft Starter

The application of the soft starter system is intended to reduce the current used to rotate the centrifugal pump motor[13]. With this system, it is expected that the current entering the centrifugal pump motor does not exceed a predetermined limit[14]. The way this system works itself is to reduce the voltage step by step [15], [16], [17], [18], [19]. The method is to limit the voltage applied to the motor. With a low motor voltage, the current and torque values are also lower[20], [21]. This condition minimizes current surge by making the motor spin slowly. Gradually, the applied voltage will be increased until the pump motor rotates with normal rotations per minute (RPM). Soft starter has 2 main components, those are a back-to-back thyristor and a control circuit. A thyristor (commonly known as a triac) is a semiconductor that can be opened and closed to pass an electric current[22]. Therefore, the components are commonly used based on the PNPN structure. In a soft starter system, the thyristor needs to be controlled in such a way during the running cycle [23]. A control circuit in this research is used to control the voltage at the thyristor gate. For the control systems, both open loop and closed loop systems can be used. In a closed loop system, the current value used when starting will be measured by the sensor. The measurement results of this sensor will then be processed to modify the initial voltage.

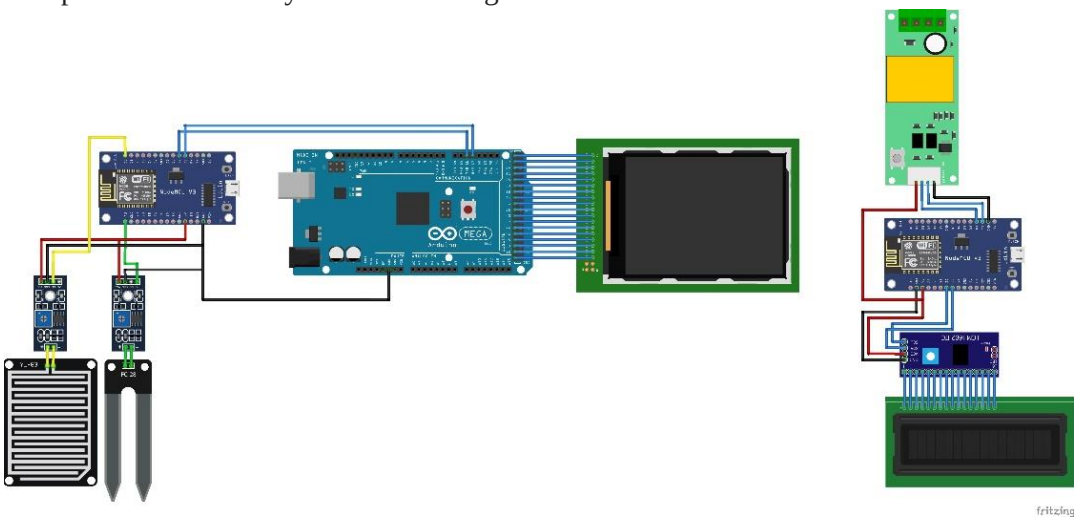


Figure 1 Wiring Diagram Monitoring System (a) and Soft Starter System (b)

B. System Design

Before designing the actual system, it is necessary to do some preparation. The preparations include making user interface designs, as well as making system models that explain how the system works. At the manufacturing stage, the designs that have been made in the previous stage will be realized into the actual system. The stage is divided into two activities to be carried out. First, the manufacture of hardware both from the pump system and monitoring system accompanied by a light trap. In addition, its software is also designed to display physical variables that have been measured by the sensor. This software also functions to control the pump.

C. System Testing

Once the design stage has been done, the system will be tested. First, the work of each component on the system will be tested. As an example, sensor measurement testing to determine the error value that occurs. Besides hardware testing, software performance is also shall be tested. Tests are carried out on the function of each feature in the application, especially in integrating with hardware's. Then this system will also be assessed on its performance, stability, and reliability if it is implemented in the community.

III. RESULTS

A. System Design and Test Results

The results of hardware design and test show that the value of the static characteristics of each sensor along with the results of software test. Based on the research that has been done, the soil moisture sensor has an accuracy of 98.27%. The accuracy value is obtained with an average error value of 1.5%.

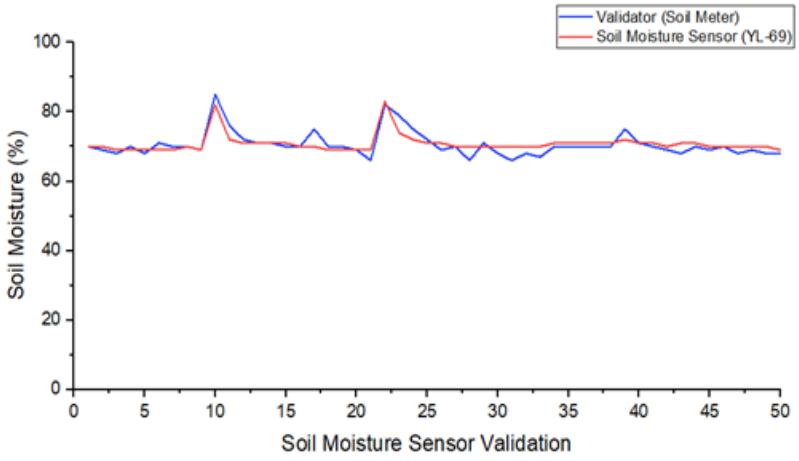
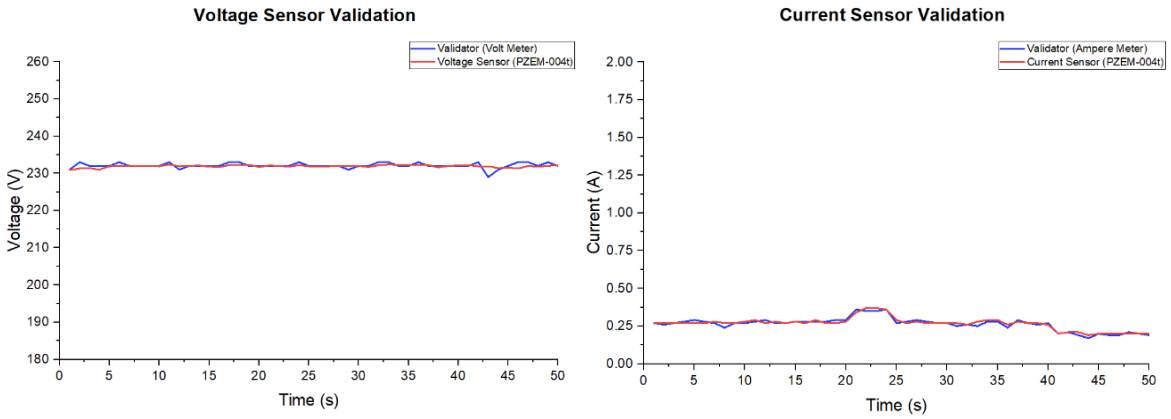


Figure 2. Soil Moisture Sensor Validation

In addition to the soil moisture sensor, validation of the PZEM004t sensor readings was also performed. The sensor can be used as an AC current and voltage sensor. This sensor can also simultaneously read energy, power, frequency, and power factor. Figure 3 shows the results of the PZEM 004t sensor readings on the AC current and voltage values. From these data, the accuracy value of the sensor for current readings is 99.63%. Meanwhile, the accuracy of voltage reading is 99.87%.



(a) (b)

Figure 3. Voltage (a) and Current (b) Sensor Validation

Figure 3. Binary Image

B. Solar Light Trap Application Results

The light trap in the system consists of three white LED lamp units with a voltage of 12 Volt DC. The three lights are powered by a 42Ah 12 Volt battery that has been charged by 100Wp solar panel during the day. The light trap system in this research uses a photocell as an automatic switch when the light in the environmental conditions gets darker or the light intensity is below 5 lux. After 13 hours of use, the 42 Ah battery can be used as a light trap resource as well as a monitoring system.

Figure 4. Light Trap

C. Soft Starter Application Results

It is known that before using the soft starter the highest current measured was 3.2 Ampere. Meanwhile, after using the soft starter, the highest current value measured is 2.28 Ampere until 2.77 Ampere. Then from the overall data, the average value of each test is taken. Based on these data, it is known that the use of a soft starter can reduce the current value by 21.09%.

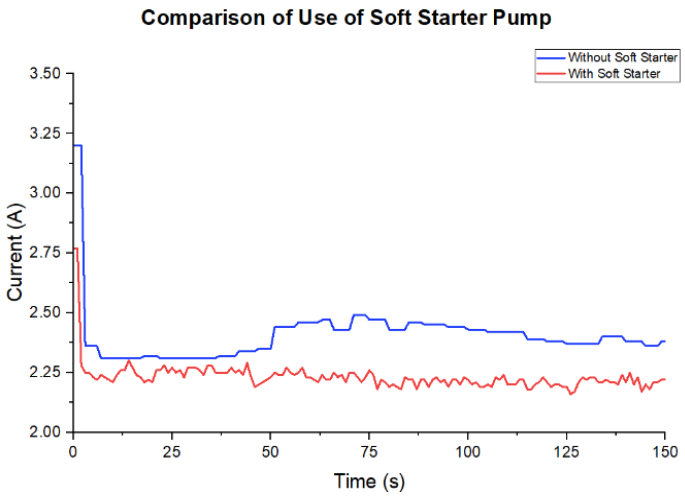


Figure 5. Current Reduction Using Soft Starter

After obtaining data about current reduction by using a soft starter on the pump, it can be analyzed how efficient this method is compared to other methods. In this research, the comparison with the system that has been made is the cost of conventional irrigation that has been used and the cost of irrigation with a 250-watt pump but without using a soft starter. The conventional irrigation method referred to a service that farmers use to pump water from water sources to their agricultural land [24], [25], [26], [27], [28]. Based on previous interviews, the cost of this service is IDR 35,000 per hour. From this comparison, various aspects are then analyzed that can be used to measure the level of efficiency of the system that has been made. As for this analysis, the aspects used are the length of time for irrigation, costs, effects on the environment, and additional features in the form of monitoring. Based on laboratory-scale tests on the pump system and interviews with partners, the following data were obtained:

Table 1. Comparing of the Technologies

No	Aspect	Irrigation Method		
		Conventional	**Pump Without Soft Starter**	**Pump With Soft Starter**
1	Irrigation time	4 hours	6 hours	6 hours
2	Total cost per irrigation implementation	Rp140.000	Rp1.826	Rp1.767
3	Effect on environment	Not environmentally friendly	Environmentally friendly	Very environmentally friendly
4	Monitoring features	No	No	Soil moisture, rain, current, power, energy

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the research that has been done, the use of soft starter can reduce pump current by about 21.09%. In addition, it was found that the soil moisture sensor has an accuracy of 98.27%, while the PZEM 004t sensor has an accuracy of 99.63% for current readings and 99.87% for voltage readings. This system is integrated with an android application so that it can be easily used by farmers if they are connected to the internet network.

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