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Research Article

Design and Application of PLC-Based Salinocontrol Machine Integrated with IoT for Milkfish Ponds in Ujung Watu Village, Jepara

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Abstract. Milkfish farming in coastal ponds of Ujung Watu Village, Jepara, is highly influenced by the stability of water salinity levels. Significant fluctuations in salinity can interfere with the growth and health of fish, so an adaptive control system is needed. Research methods include field data collection, hardware and software design, and system testing in an active pond for 14 days (23-hour sampling), where data is extracted for 23 hours. The system uses a salinity sensor to detect water conditions, PLC to automatically control the brackish water pump, while wireless remote control uses IoT, in addition to controliing, IoT to send data to the Android-based monitoring platform. The test results show that this machine is able to maintain salinity levels within the optimal range of 10000-30000 ppm, and provide remote monitoring convenience to pond farmers. The monitoring system serves as a predictive for manual wireless control of electric pumps (IoT), while automatic control is controlled by PLC.

Keywords: IoT; Salinity Control; Salinocontrol Machine; System Automation; PLC

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1. Introduction

Pond is an aquaculture system that is highly dependent on environmental balance, especially on the aspect of salinity[1] . Cultivation of milkfish (Chanos chanos), one of the main commodities in coastal areas of Indonesia, requires optimal salinity levels to achieve high productivity. In Ujung Watu Village, Jepara, pond farmers face the challenge of fluctuating salinity levels due to the influence of weather and water supply, which has a direct impact on the growth and survival of milkfish.

Various approaches have been taken to maintain salinity stability, such as manual monitoring using a refractometer and conventional water replenishment, but these methods have disadvantages in terms of time efficiency, accuracy, and dependence on human labor.

Technology-based alternatives, such as the use of salinity sensors and automation systems, are beginning to be introduced, but most have not been thoroughly integrated with PLC and IoT-based control systems.

In this research, a Salinocontrol machine is developed that uses a digital salinity sensor to detect salt levels in pond water in real time, a PLC (Programmable Logic Controller) to regulate brackish or fresh water filling pumps automatically, and an IoT (Internet of Things) module to be able to monitor remotely through an Android application. This technology integration is expected to be able to overcome the problem of salinity fluctuations with precise and responsive control.

The main problem to be solved is how to design a salinity control system that is capable of working automatically and can be monitored remotely by pond farmers, while increasing the efficiency and effectiveness of milkfish farming. The proposed approach is the merging of PLC and IoT technologies in one integrated control system based on salinity sensors.

The main objectives of this research are the design of a PLC and IoT-based Salinocontrol system, implementation of the system in an active pond environment, and analysis of the effectiveness of the system in maintaining pond salinity within the optimal range.

2. Literature Review

Research[2] on salinity control systems in automation-based ponds and the Internet of Things (IoT) is growing along with the increasing need for precision aquaculture. One of the studies entitled Optimization-based online initialization and calibration of monocular visual-inertial odometry considering spatial-temporal constraints by W.Huang et al., showed that the application of sensors and IoT devices can perform direct and remote water quality monitoring, but the control has not been fully integrated into the PLC system.

Another research[3] titled PLC based design of monitoring system for ICT-integrated vertical fish farm by J.Huh, describes a PLC-based control design for water circulation management in a closed pond, but has not implemented real-time remote monitoring features.

In the realm of[4] salinity sensor utilization and adaptive control, the article Internet of things (IoT) assisted soil salinity mapping at irrigation schema level by R. Bashir et al., describes an IoT-based control architecture that integrates conductivity sensors to precisely stabilize salinity. This study emphasizes the adaptability of control algorithms in the face of rapidly changing pond environments.

Puspitasari et al.,[5] implemented a fuzzy logic-based IoT system that monitors water parameters including salinity, and controls actuators automatically, similar to your Salinocontrol IoT architecture, although they have not incorporated a PLC in the system.

Overall, these literatures show that PLC and IoT technologies have great potential to improve the effectiveness of salinity management in ponds. However, the majority of previous research has focused on only one aspect of either PLC-based control or IoT-based monitoring and there are not many studies that integrate the two in a unified system. This research contributes to filling this gap by designing a Salinocontrol machine that integrates PLC and IoT for automatic salinity control and real-time remote monitoring.

3. Proposed Method

This research[6] uses the Design-Build Method approach which consists of five main stages, namely Requirements Analysis, System Design, Implementation, Testing, and Maintenance. Each stage has specific steps designed to ensure the system development process runs in a structured and systematic manner.

The overall flow of this method is depicted in the flowchart in Figure 1.

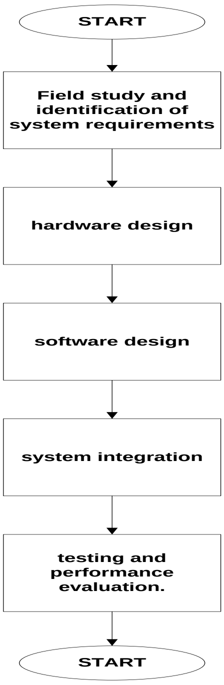

Figure 1. Research Flowchart

Figure 1 shows the flow of research methods consisting of five main stages. The process begins with field studies and identification of system requirements at the location of the milkfish farm to understand the problem of salinity fluctuations, followed by the design of IoT hardware consisting of salinity sensors, water pumps, and communication modules. For IoT software is set up, so that hardware and software can function in an integrated manner and support remote monitoring. For controlling the pump using IoT (manual) and PLC (automatic non-wireless). The last stage is a 14-day system test and evaluation (taken 23 hours out of 14 days) in the field to assess the performance of sensors, automation systems, and IoT connectivity.

3.1. Block Diagram

The system developed in this research combines Internet of Things (IoT) technology with a Programmable Logic Controller (PLC) to monitor and control electric pumps automatically and manually based on water salinity levels. The functional block diagram of the monitoring and control system is shown in Figure 2.

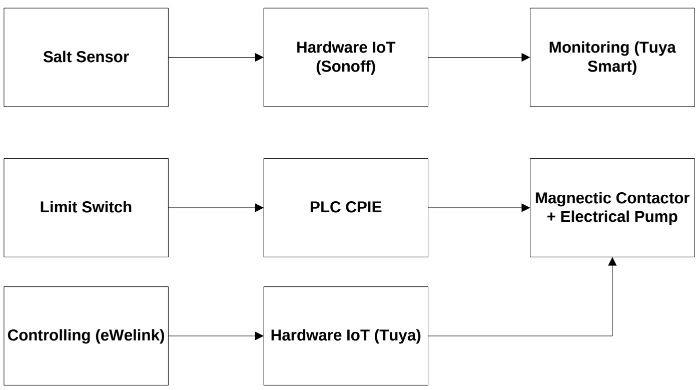

Figure 2. Block Diagram

Figure 2 shows the functional block diagram of the developed monitoring and control system. The system combines Internet of Things (IoT) and Programmable Logic Controller (PLC) technologies to monitor salinity levels and control electric pumps automatically or manually. The salinity sensor sends data to the IoT device (Sonoff) for the monitoring process through the Tuya Smart application. The limit switch detects the water level and gives a signal to the CP1E PLC, which then controls the work of the magnetic contactor and electric pump based on the control logic that has been programmed. In addition to automatic control by PLC, users can also perform manual control through the eWeLink application connected to the device.

3.2. Power Wiring Diagram

To support the process of controlling the pump automatically or manually, this system is also equipped with a power installation designed using protection components and motor controllers[7] . This installation serves to deliver electrical power to the pump drive motor safely, as well as protect the system from disturbances such as overcurrent, short circuit, and overload[7] . The main components in this circuit include a Miniature Circuit Breaker (MCB) as an initial protection against overcurrent, a magnetic contactor as an electromagnetic switch controlled by a signal from the PLC, and a thermal overload relay that functions to cut off electricity if the motor works outside the temperature limit or nominal current[7] . The 1-phase electric motor functions as an actuator to drive the water pump, according to logic commands from the control system[8] . Power Wiring Diagram is shown in Figure 3.

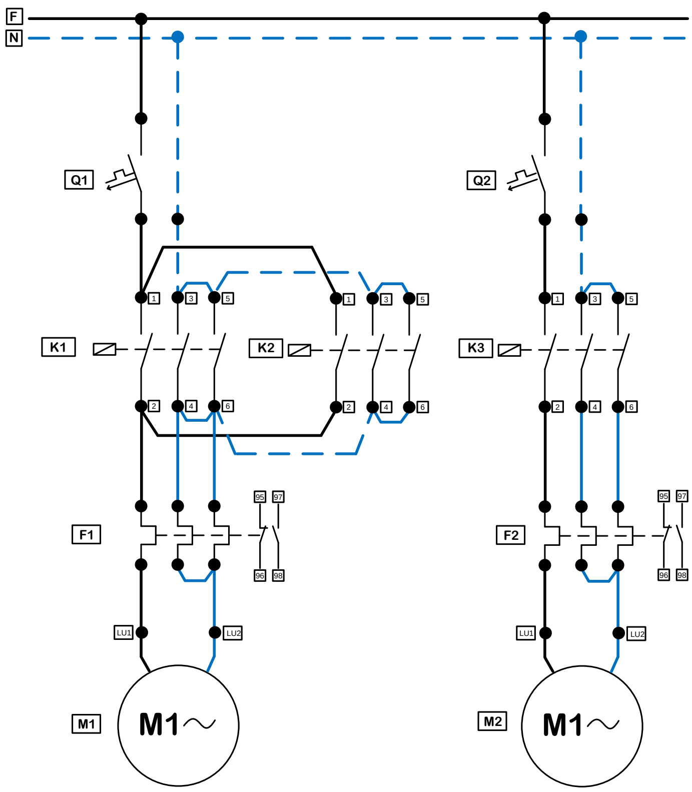

Figure 3. Power Wiring Diagram

Figure 3. shows the configuration of the Power Circuit used in the system to support the operation of the electric motor as a pump driver. The electric current from the main source first passes through the MCB as a protector against overcurrent and short circuit. Next, the current flows to the magnetic contactor which is controlled by the signal from the PLC, functioning as an automatic switch to connect or disconnect the current to the motor, before heading to the motor, the current also passes through a thermal overload relay which functions as a protection against overload, by cutting off the current if there is an increase in

temperature due to overcurrent. This arrangement is designed to ensure the effectiveness and operational safety of a 1-phase electric motor in an automatic or manual control system.

3.3. Control Wiring Diagram

To regulate the working logic of the system automatically and manually, a control circuit is used that integrates the IoT device and PLC as the control center[9] . The control circuit is in charge of connecting the signal from the LS to the actuator output[10] . Through this integration, the system can respond to changes in water conditions based on the concept of buoyancy, if the salinity is low, the buoyancy sinks, if the salinity is high, the buoyancy floats (automatic mode), and can be controlled manually from a distance[10] . Emergency stop and thermal overload relays play an important role in maintaining system safety while operating. The complete control wiring diagram is shown in Figure 4.

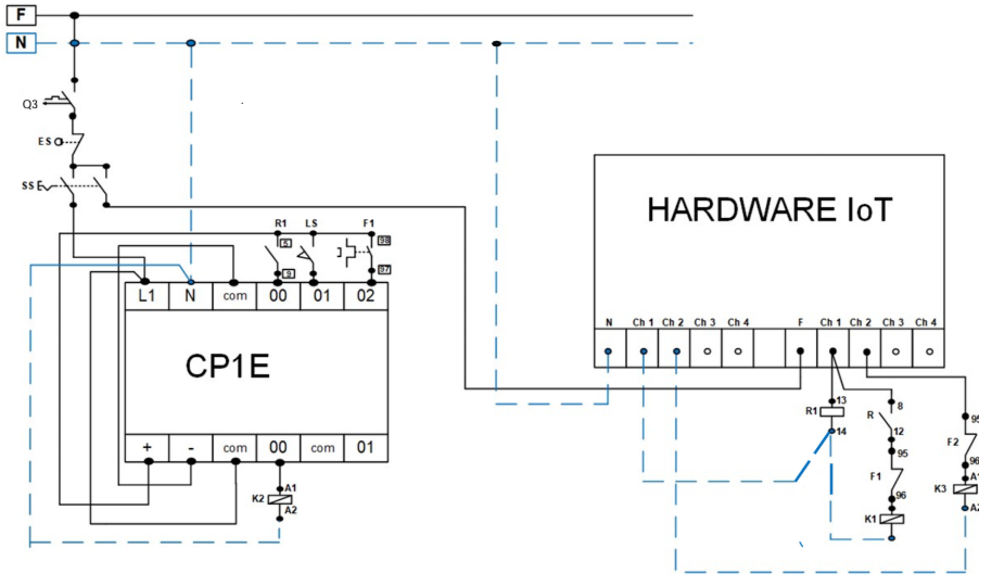

Figure 4. Control Wiring Diagram

Figure 4. shows the configuration of the control circuit that integrates the IoT device and PLC as the logic control center of the system. The signal from the limit switch (LS) connected to the floatation mechanism is used as an input to indirectly detect the water salinity condition. When the salinity is low, the floats sink and activate the limit switch; conversely, when the salinity is high, the floats will float and trigger a different condition on the LS. This signal is processed by the PLC to activate or deactivate the actuator, which is the water pump, through the MY4N relay and magnetic contactor. An IoT device (Sonoff) is also connected to the system, allowing users to perform manual control remotely through the app. The system is equipped with an emergency stop for emergency stoppage and a thermal overload relay as protection against overloading the motor. This combination results in a control system that is responsive, safe, and flexible in both automatic and manual operation.

3.4 Wiring Diagram of Monitoring

To monitor the salinity condition of pond water in real-time, this system is equipped with a sensor-based monitoring circuit and IoT[11] . The salinity sensor serves to detect salt levels in water[12] . Tuya IoT hardware is used to execute signals from sensors and wirelessly integrated with the android application[13] . The adapter is used as a power supply for sensor modules and IoT devices .[14]

Wiring Diagram of this monitoring is shown in Figure 5.

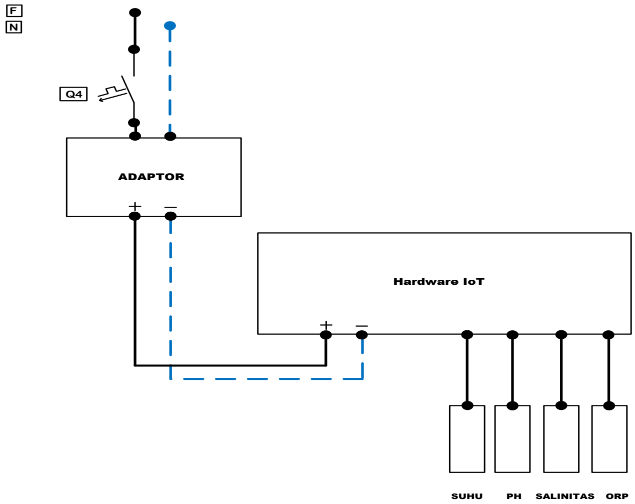

Figure 5. Wiring Diagram of Monitoring

Figure 5. shows the Wiring Diagram of Monitoring which consists of a salinity sensor, adapter, and Tuya IoT hardware. The salinity sensor detects salt levels in water and sends data signals to the Tuya device, which then transmits the information wirelessly to the Android application via an internet connection. The adapter functions as a power supply, converting the power source to the appropriate voltage to support the operation of the sensor and IoT device. The integration of components can monitor the condition of pond water salinity in real-time from a short distance (wireless), even remotely without the need to manually check on site, thereby increasing efficiency and responsiveness in pond management.

4. Results and Discussion

4.1 SSDP (Control Panel)

In this research, Salinocontrol machine is designed and made to monitor and control water salinity in milkfish ponds using PLC (Programmable Logic Controller) technology integrated with IoT (Internet of Things)[14] . The hardware used includes salinity sensors, Omron CP1E PLC, 1-phase electric motor to drive the water pump, as well as IoT Hardware for controlling Electrical Pump and monitoring water. The software used is eWelink and Tuya Smart[14] . The Control Panel is shown in Figure 6.

Figure 6. SSDP (Control Panel)

Figure 6. shows SSDP as the main control panel that integrates PLC, IoT devices, salinity sensors, MCBs, relays, and magnetic contactors. This panel serves to control and monitor the system automatically and manually in a safe and centralized unit.

4.2 Electrical Pump

To automatically regulate water circulation according to salinity conditions, this system uses an electric pump as the main actuator[10] . The pump serves to drain water in and out of the pond, both from freshwater and brackish water sources, depending on the needs of the system[10] . The working circuit of the pump is shown in Figure 7.

Figure 7. Electrical Pump

Figure 7. shows the electric pump used to regulate water flow in the system. The pump is connected to an inlet to draw water from the source and an outlet to deliver it to the pond. The pump is activated automatically based on commands from the PLC, which responds to signals from the salinity sensor and limit switch. This system ensures that the water circulation runs according to the salinity needs of the ponds, both for the addition of fresh water when salinity is high and the addition of brackish water when salinity is low.

4.3. Android Application Software

To support remote monitoring and control functions, this system is equipped with an Android application that is integrated with the IoT device[15] . The eWeLink application is used for manual control of the pump through the Sonoff device, while the Tuya Smart application is used to monitor real-time salinity data from the connected sensor[15] . The display of both applications is shown in Figure 8.

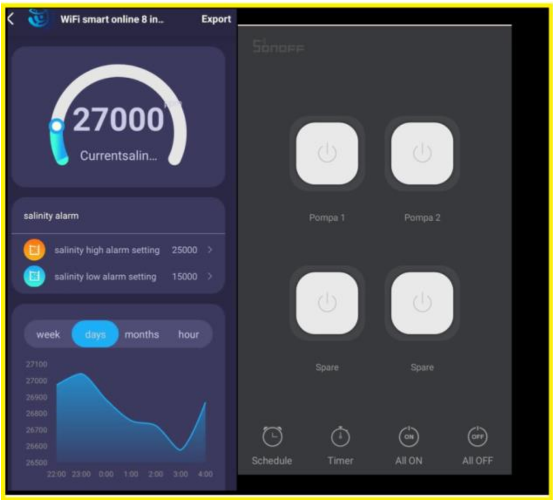

Figure 8. Android Application Software Display

Figure 8 shows the interface of the eWeLink and Tuya Smart applications used in the system. Through eWeLink, the user can manually activate or deactivate the pump. Meanwhile, Tuya Smart displays salinity data directly from the sensor, allowing users to monitor pond water conditions anytime and anywhere. The integration of these two applications makes it easy to monitor and control IoT-based systems practically and efficiently.

4.4. Data and Field Testing

Testing was conducted in an active milkfish pond located in Ujung Watu Village, Jepara, for 14 days (23-hour sampling). Data in the form of salinity values were collected every 1 hour and stored in a cloud database accessed by the Android application. The initial salinity of the pond was in the range of 29,000-31,000 ppm, exceeding the optimal threshold (10,000-25,000 ppm) for milkfish cultivation.

4.4. Measurement and Evaluation Results

Based on the test results, the system can maintain water salinity in the range of 15,000-25,000 ppm with a tolerance of ± 2000 ppm[16] . Salinity/hour Data Table and Pump Status can be seen in Table 1.

Table 1. Salinity Data and Pump Status

DateTime	Salinity (ppm)	PUMP STATUS	
2025/06/23 00:00	26098	OFF	
2025/06/23 01:00	26181	OFF	
2025/06/23 02:00	26358	OFF	
2025/06/23 03:00	26561	OFF	
2025/06/23 04:00	26473	OFF	
2025/06/23 05:00	26394	OFF	
2025/06/23 06:00	26386	OFF	
2025/06/23 07:00	26432	OFF	
2025/06/23 08:00	26500	OFF	
2025/06/23 09:00	26431	OFF	
2025/06/23 10:00	26475	OFF	
2025/06/23 11:00	0	PLN electricity off	
2025/06/23 12:00	0	PLN electricity off	
2025/06/23 13:00	0	PLN electricity off	
2025/06/23 14:00	0	PLN electricity off	
2025/06/23 15:00	24766	OFF	
2025/06/23 16:00	26276	OFF	

2025/06/23 17:00	26297	OFF	
2025/06/23 18:00	26515	OFF	
2025/06/23 19:00	26168	OFF	
2025/06/23 20:00	27084	ON	
2025/06/23 21:00	27019	ON	
2025/06/23 22:00	26976	OFF	
2025/06/23 23:00	27046	ON	

Table 1. Shows the recorded data of pond water salinity in ppm and the operational status of the automatic pump on June 23, 2025. Data is recorded once every hour by the monitoring system. It can be seen that the salinity fluctuated in the range of 24,766 to 27,084 ppm, but the pump remained OFF until 20:00, when the salinity exceeded the predetermined threshold and the pump was turned ON. From 11:00 to 14:00, there was a PLN power outage that caused salinity data not to be recorded and the pump did not operate. Pump activation reflects a control system that runs according to the logic of threshold-based salinity control.

4.5. Discussion

The test results of the Salinocontrol system show that this system is able to effectively maintain the stability of pond water salinity in accordance with the needs of milkfish farming. When the salinity is outside the optimal limit, the system automatically activates the pump to add fresh or brackish water to stabilize the salt content in the pond. This proves that the control algorithm designed through the integration of PLC and Internet of Things (IoT) is able to respond to changes in water conditions quickly and precisely.

The main advantage of this system lies in its ability to perform sensor-based automatic control and at the same time provide real-time monitoring to users through an Android application. With salinity information displayed directly, farmers can perform predictive monitoring, which anticipates unwanted conditions before they occur. In the event of constraints in the automated system, farmers still have the option to take over control manually through the eWeLink application. The effectiveness of this system is reinforced by research by O. O. Olanubi, T. et al., who stated that the integration of PLC and IoT in fisheries automation systems can improve operational efficiency, especially in the aspect of water quality control, with reduced manual intervention, time, effort, and potential human error can be minimized.

The Salinocontrol system is also characterized as adaptive to the dynamics of the pond environment. Changes in salinity levels that occur due to rain, evaporation, or seasonal changes can be responded to by the system flexibly. This supports the results of studies that emphasize the importance of adaptivity in control systems to support the sustainability of aquaculture. In this study, adaptivity includes not only the ability to detect changes, but also the capacity of the system to respond to those changes in real-time. Overall, the results of this study show that the use of PLC and IoT-based systems in salinity management of milkfish ponds provides not only technical efficiency, but also operational flexibility, and supports a smarter, modern, and data-driven approach to aquaculture.

5. Comparison

Evaluation of the performance of the Salinocontrol machine developed, a comparison was made with similar technologies in the context of pond salinity control based on automation and IoT. The study by O. Olanubi, T et al., developed a microcontroller-based system to regulate water discharge based on TDS sensors, but has not been equipped with Android application-based monitoring and only relies on semi-automatic systems[17] . Developing an ESP32-based system with remote monitoring capabilities, but pump control is still limited to manual settings via the application, compared to these two systems, this research contributes in the form of integration of automatic control through PLC and IoT-based predictive monitoring system. The test results show that the salinity range stabilized at 15,000-25,0000 ppm during the 14-day test (23-hour sampling). This outperforms previous research that was only able to maintain a range of salinity stability with a deviation of ±1.2 ppt.

Another advantage of this system is the ease of integration with Android applications designed to be user-friendly for pond farmers, as well as the use of conductivity-based salinity sensors that have high durability in brackish water environments. Thus, the proposed system is not only efficient in maintaining the quality of the pond environment, but also supports digital transformation in aquaculture.

6. Conclusions

This research successfully designed and implemented a PLC-based Salinocontrol machine integrated with IoT to maintain the salinity stability of milkfish ponds in Ujung Watu Village, Jepara. The system is able to maintain salinity within the optimal range of 15,000-25,000 ppm with high accuracy, and supports remote monitoring through Android applications. The results show that the integration of PLC and IoT technology is effective in supporting automation and predictive decision-making, which contributes to the development of precision agriculture in the fisheries sector.

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