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Design of Aeration Control System in Aquaculture

Van-Anh Bui [1], Quang- Van Vu[1*], Quoc-Tuan To[2]
[1]*Department of Electrical and Mechanical Engineering, HaiPhong University, HaiPhong, Vietnam*
[2]*Service and Boarding Center, HaiPhong University, HaiPhong, Vietnam*

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ABSTRACT: The energy problem is one of the biggest challenges the world faces. Saving energy not only helps reduce costs and protect the environment but also contributes to ensuring energy security and sustainable development. For the shrimp farming industry, electricity consumed by aeration systems accounts for about 80% of the total energy used by shrimp farms. Statistics from the shrimp farming industry also show that electricity costs in shrimp farming currently account for 11 - 14% of the cost. Therefore, saving energy not only helps reduce costs and protect the environment but also contributes to ensuring energy security and sustainable development of each country.

This article studies a new control system with an acceptable cost but still meets standard technical requirements. To achieve this, the control system must renovate and upgrade the motors used in shrimp farms using inverters to save energy and control the rotation speed according to the morning, noon, and afternoon periods. , dark depends on the amount of oxygen changing during the day as well as the amount of food the animals eat. In addition, the controller can be combined with sensors to create a closed feedback loop according to the technical process that responds to the oxygen saturation in the water. The capacity and quantity of aeration motors can be optimally designed depending on the area or amount of aquatic animals raised. In this article, the authors research and apply industrial inverters to control aeration motors, with PLC controllers and modern data collection monitoring systems. This is the premise for research and application of science and technology in agriculture.

KEYWORDS: Aquaculture; DO concentration; Control and monitoring; Industrial inverter;

I. INTRODUCTION

Recently, there have been a number of projects and solutions to save electricity consumption in aquaculture in general and the shrimp farming industry in particular [1]. The solutions focus mainly on the power transmission stage of the Engine - Propeller electric drive system and the use of alternative energy sources [2] and [3]. Some solutions can be mentioned as follows: One is the solution to improve the oxygen fan system to save electricity in aquaculture to improve the drive shaft of the motor to be coaxial with the rotation axis of the fan system [4] and [5].By applying this solution, it is calculated that 35-40% of electricity consumption can be saved. The second solution to improve efficiency in providing and using electricity in aquaculture areas and aquaculture lakes is to use a 400V-25uF single-phase condenser connected in triangle to form a power compensator. 3-phase power helps reduce power loss, improve the load-carrying capacity of conductors and the grid, and improve and enhance voltage quality for loads [6], [7] and [8]. Third, the solution of researching and applying energy sources to replace grid electricity in aquaculture is also mentioned [9] and [10].

However, applying an inverter to control the aeration pump motor is one of the simple but highly effective solutions. This solution is not synchronous but only stops at installation advice from companies. There are no projects or research on the efficiency that inverters bring, and there is no automatic controller to increase or decrease. aeration motor speed when DO concentration changes [11] and [12].

The research work of the author group when completed is a general work that mentions different control modes allowing users to choose manual, semi-automatic or fully automatic control modes. Fully compatible with different forms of shrimp farming: Intensive, super-intensive or semi-intensive. The content of the article is divided into 5 parts as follows: After the introduction, there is an overview of the research content presenting the aquaculture system and proposing a research model, part 3 is the circuit design. electricity and system control programming, part 4 builds the control and

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monitoring interface on the HMI screen, and finally part 5 concludes.

II. RESEARCH CONTENT

In aquaculture, the dissolved oxygen content in water (also known as DO) plays a decisive role in the development of cultured animals. Two common methods are providing oxygen through enhancing the water-air contact surface on the water surface and using a compressor to blow air into the underwater pipeline system as shown in Figure 1 and Figure 2

a) Pump-aerator

SOME TYPES OF AIR BLOWERS WITH COMPRESSORS

a) Mechanical aerator

b) Paddle wheel aerator

TYPES OF WATER SURFACE AERATORS

Design a power supply system for the mains motor combined with a solar energy system with conversion through the ATS. The operating principle of a fully automatic system is essential for aquaculture ponds, especially high-density shrimp farms. In case of a power outage, farmers do not know how to start the backup aeration system, affecting quality, productivity and financial loss. The power supply system described in the drawing below ensures that the power supply is continuously maintained. When the grid power is lost, the backup power source will start, continuously supplying power to the aeration system.

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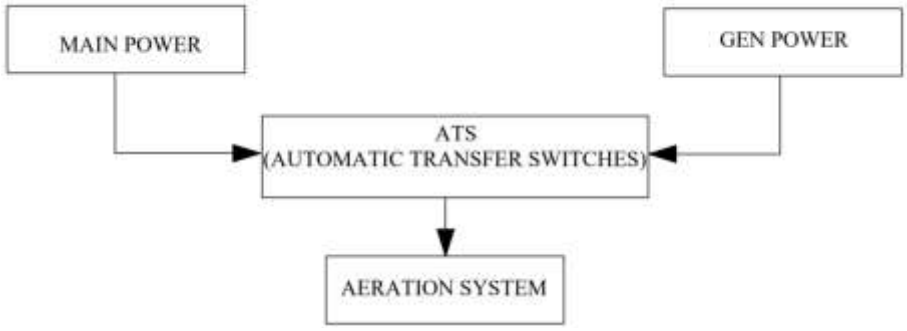
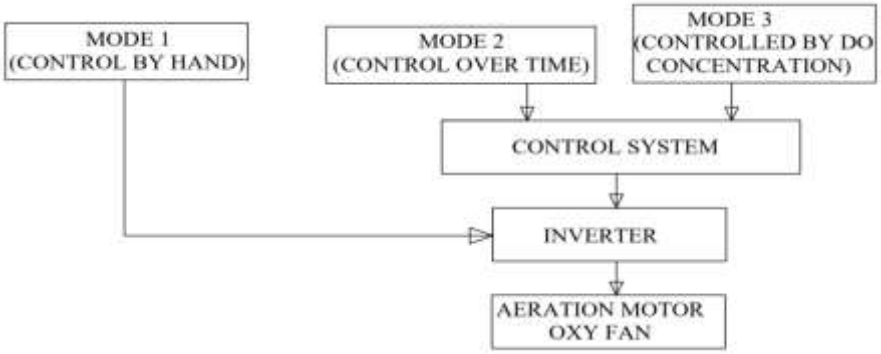


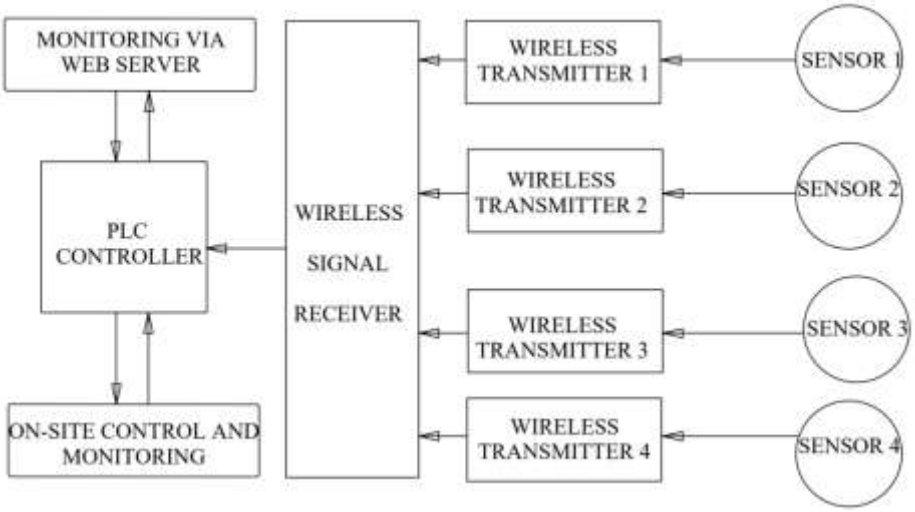
POWER SUPPLY SYSTEM MODEL

The control system flexibly uses control modes to suit the needs of the owner. Using a system with three flexible modes as above is necessary to ensure safety in aquaculture.



MODEL OF PROPOSED CONTROL MODES

Design a monitoring and control system using an inverter to control aeration motors for aquaculture lagoons. The smart monitoring system targets parameters that need to be monitored such as pH, salinity, clarity, temperature... through corresponding sensors. These parameters will be displayed as warnings via the Web Server to help farmers take proactive measures to use specialized technical measures to restore water parameters to meet technical requirements. The monitoring system focuses on three main elements: one is transmitting wireless sensor signals to the controller through a wireless transmitter; second is on-site monitoring via HMI screen; Third is remote monitoring via Web server.



INTELLIGENT CONTROL AND MONITORING SYSTEM

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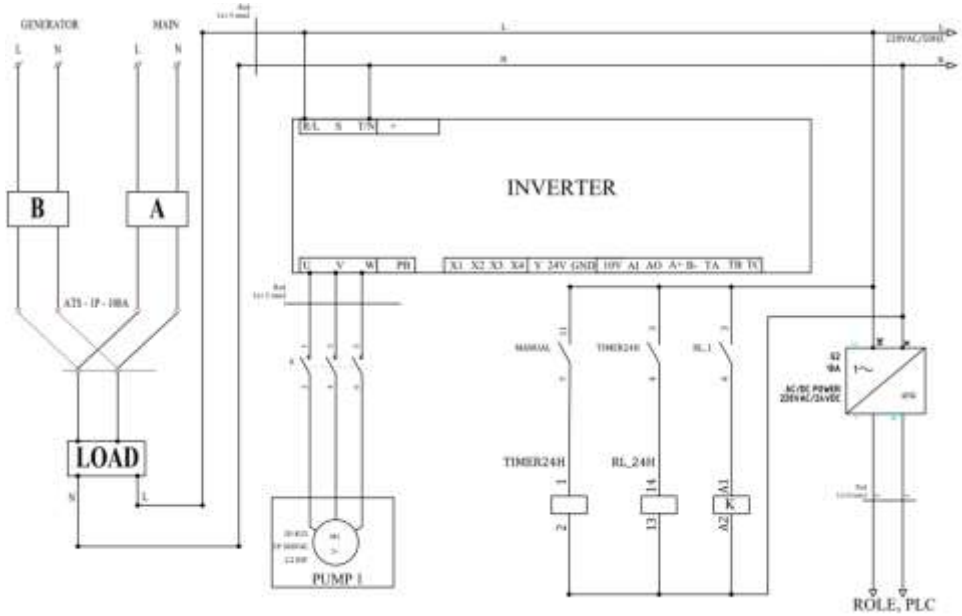
Fabrication and assembly of aeration motor controllers to save energy are carried out according to the technological process of single production to serve as a basis for evaluating and selecting the necessary equipment to assemble the system. Motor control: Choose inverter, choose sensor, choose control communication method... perfect technology towards mass production.

Device statistics table:

	Device	Describe	Unit	Quantity
1	Sensor DO		PCS	1
2	Domino	Size 1mm	Set	10
3	Role	24V DC	PCS	6
4	Contactor MC50-100A	LS	PCS	1
5	Indicator light 220V	Yellow light + Blue light	PCS	8
6	Indicator light with horn 22 220V	-	PCS	1
7	Emergency stop	-	PCS	1
8	2-mode rotary button	-	PCS	1
9	Aptomat	50 A	PCS	2
10	Power	24V	PCS	1
11	PLC S7-1200	CPU1212DC/DC/DC	PCS	1
12	HMI screen		PCS	1
13	3 Phase Motor	2,2 KW	PCS	1
14	Inverter		Set	1

III. CIRCUIT DESIGN AND CONTROL PROGRAMMING



CIRCUIT DIAGRAM POWERING THE SYSTEM

Close Aptomat A and B supply 220 VAC AC power to the ATS converter. The inverter will be supplied with 220VAC input, 380VAC output voltage.KM1 will be supplied with 380VAC power from the inverter to start the PUMP 1 aeration pump and at the same time the converter supplies 24VDC DC power to the PLC controller.

When the button switches mode to MANUAL, the suction coil RL_MANUAL has power, the contacts flip state, the normally open contact RL_MANUAL (11-7) closes so that 220VAC power is supplied to pins 1,2 of TIMER24H. When TIMER24H is turned on, pins 3

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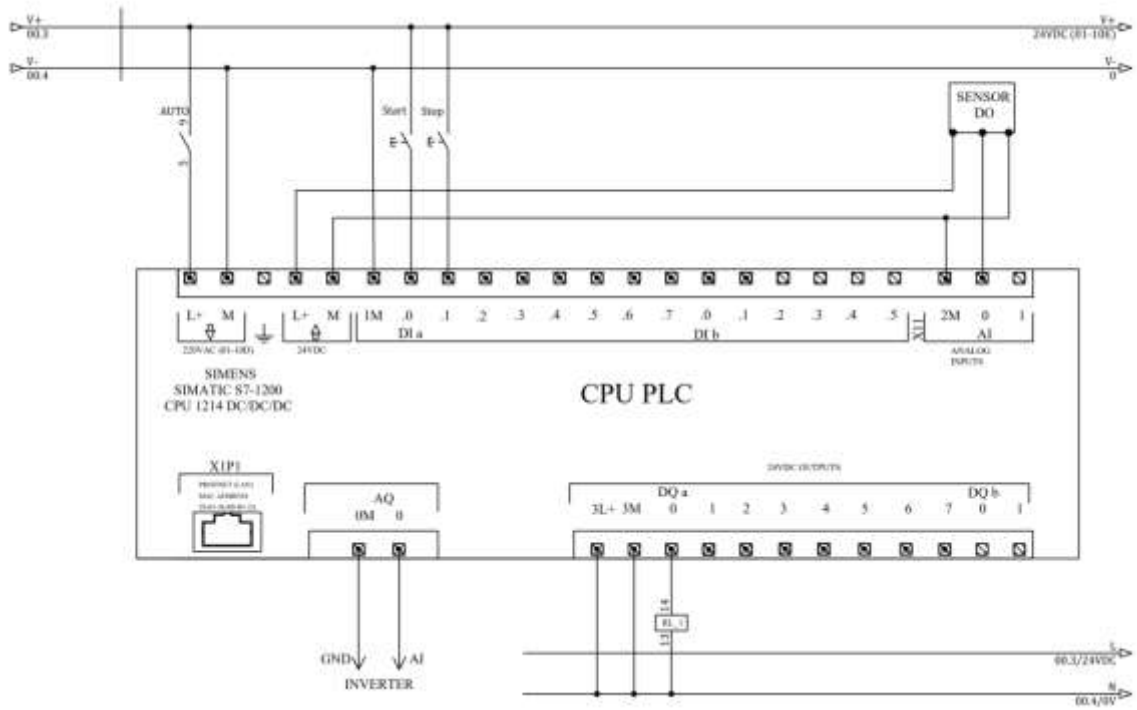
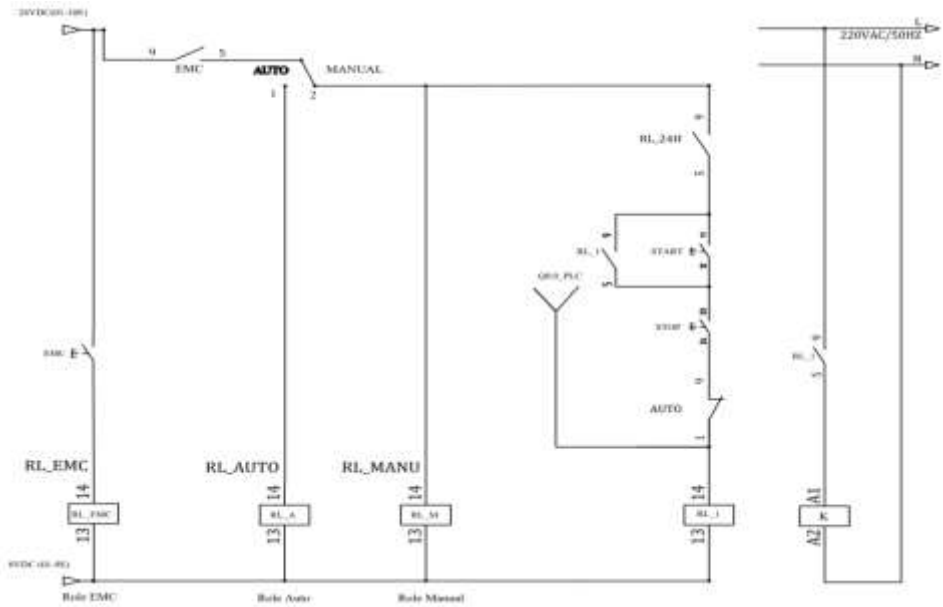
and 4 of TIMER24H supply the suction coil of RL_24H.



CIRCUIT DIAGRAM CONNECTED TO PLC

The PLC input will be connected to the start and stop push button signals, the PLC's 24VDC source is supplied to the DO sensor. The signal pin of the DO sensor will be sent to pin 0 of ANALOGINPUTS. When there is an input signal, the PLC will output the output signal according to the control program. The PLC output will be connected to the intermediate Role RL1. This role plays an intermediate role in opening and closing RL_RL1 (9-5) to control suction coil K1 according to the PLC signal.



CONTROL CIRCUIT DIAGRAM AND INTERMEDIATE RELAY

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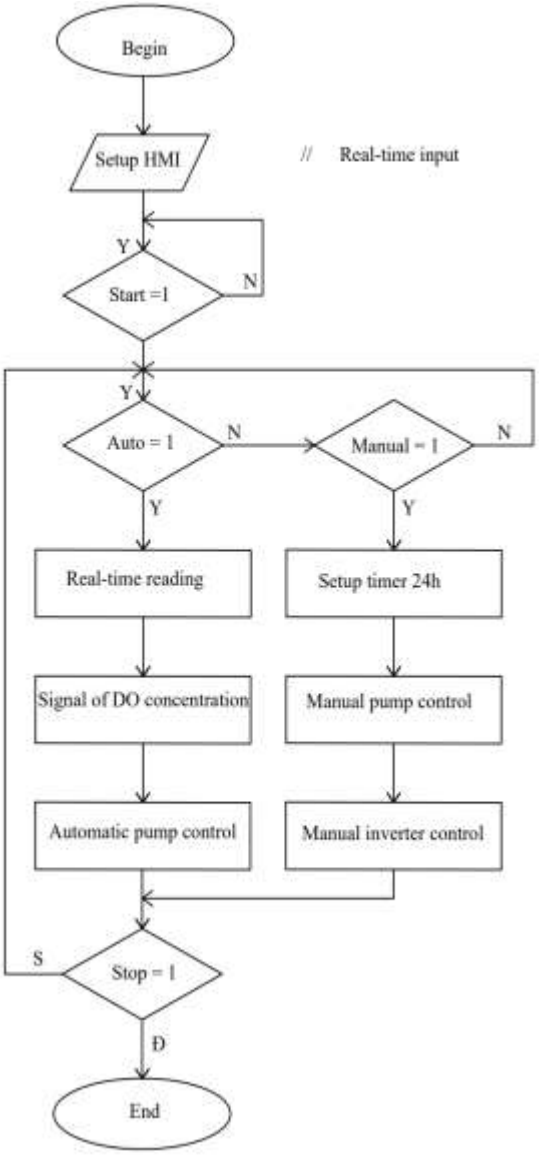
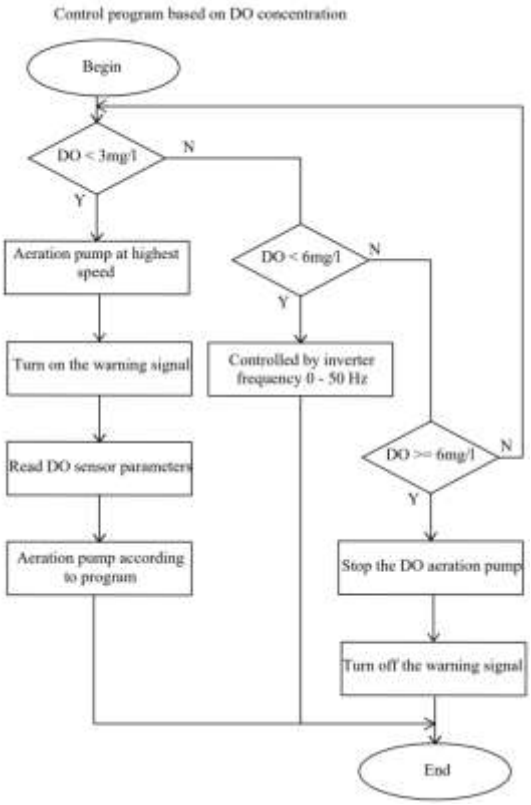
When the button switches mode to Auto, the suction coil RL_AUTO has power, the RL_AUTO contacts flip, the normally closed contact RL_AUTO (9-1) will open to ensure the system starts in Auto mode.





MAIN PROGRAM EXPLANATION **CONTROL PROGRAM ALGORITHM**

Input and output planning table:

Input	
I0.0	Auto button
I0.1	Stop button
AI 0	Analog input
Output	
Q0.0	Run Inverter
Q0.1	Start indicator light
Q0.2	Stop indicator light
AQ0	Analog output

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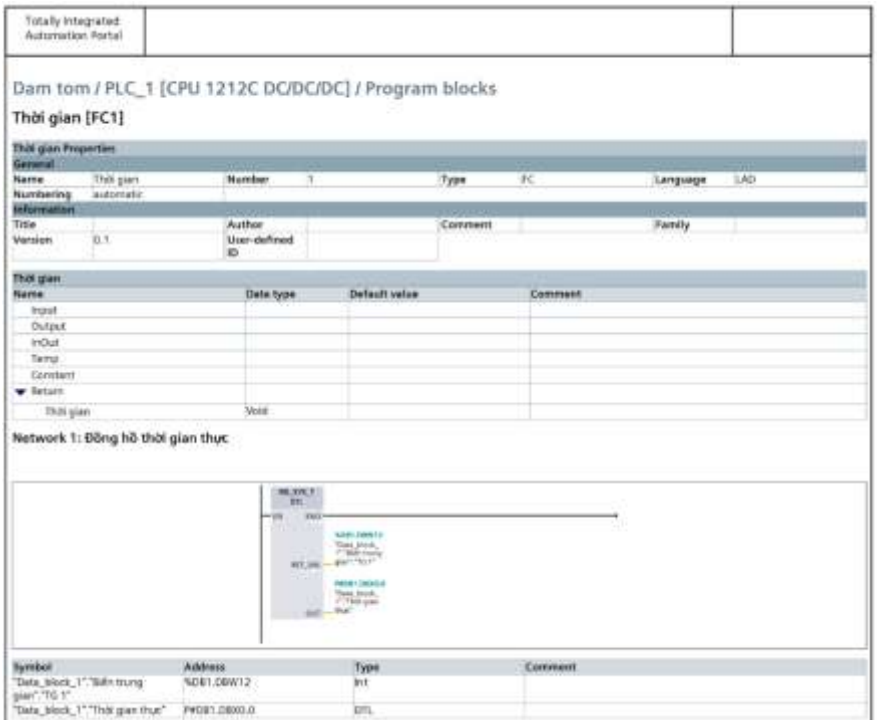
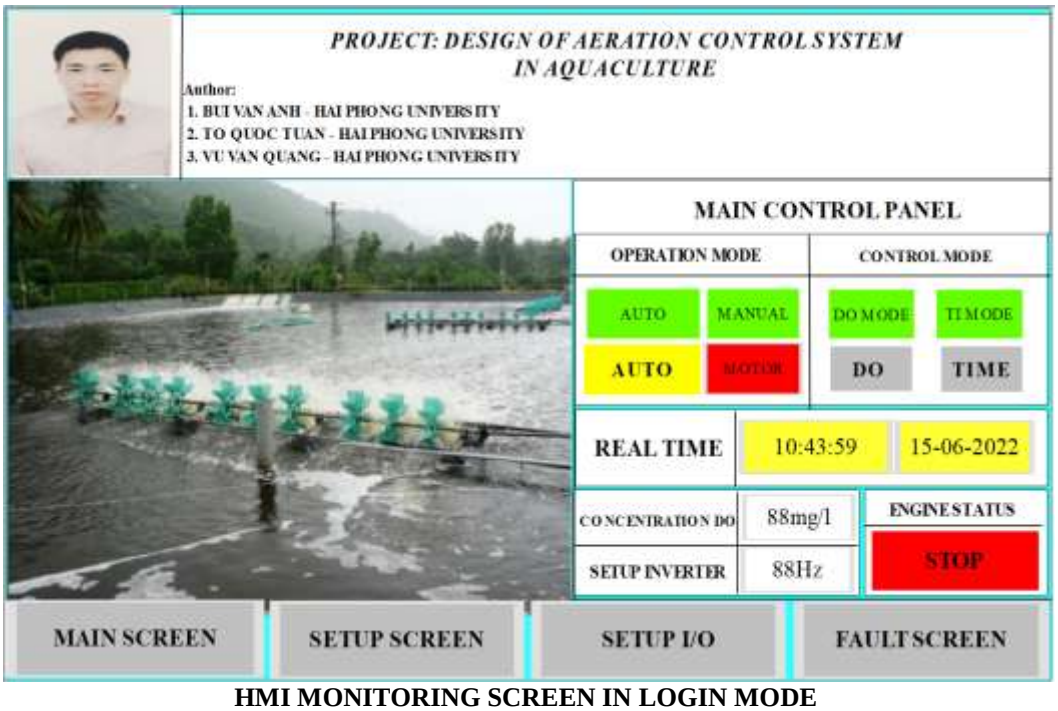


A SEGMENT OF THE S7 1200 PLC CONTROL PROGRAM

IV. RESEARCH, MONITOR AND TEST THE SYSTEM

SK Tool is software that helps programmers design SamKool HMI screen interfaces on computers. Then, download the designed program from the PC to the SamKool HMI for operation. In addition, SK Tool also allows importing data available on SamKool HMI to the computer for editing or importing from another project.



HMI MONITORING SCREEN IN LOGIN MODE

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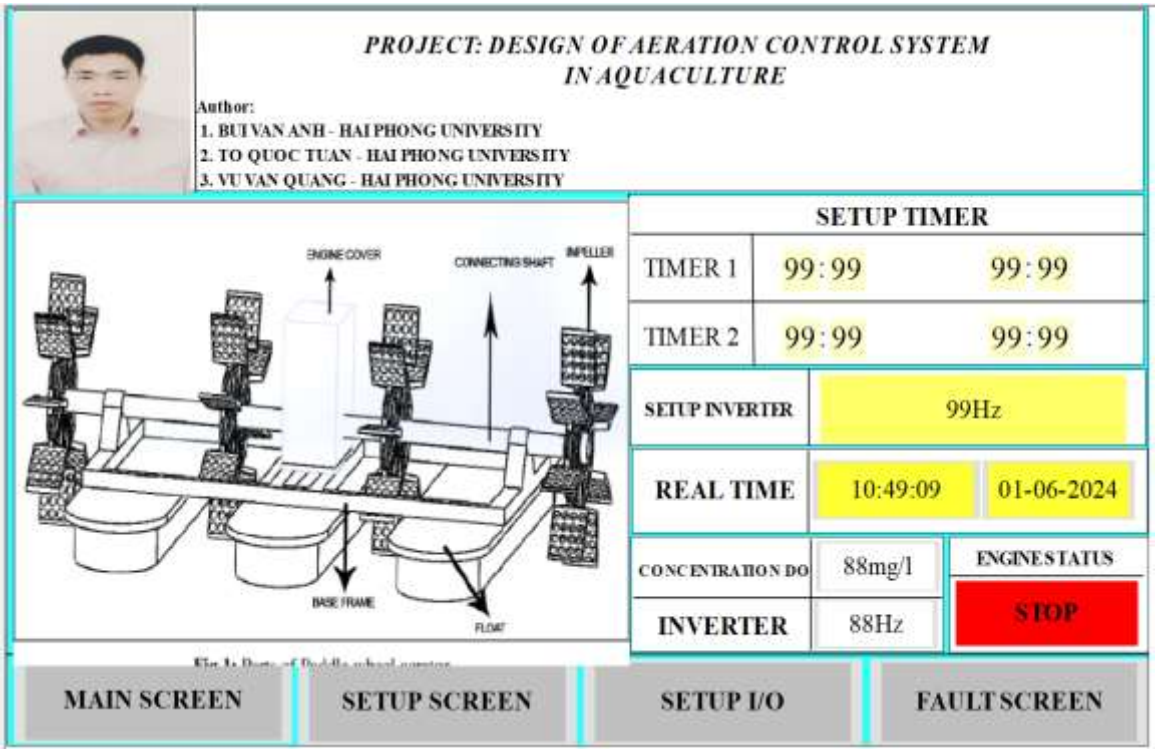

HMI SCREEN OF OPERATING MODES

HMI SCREEN SHOWS ERROR

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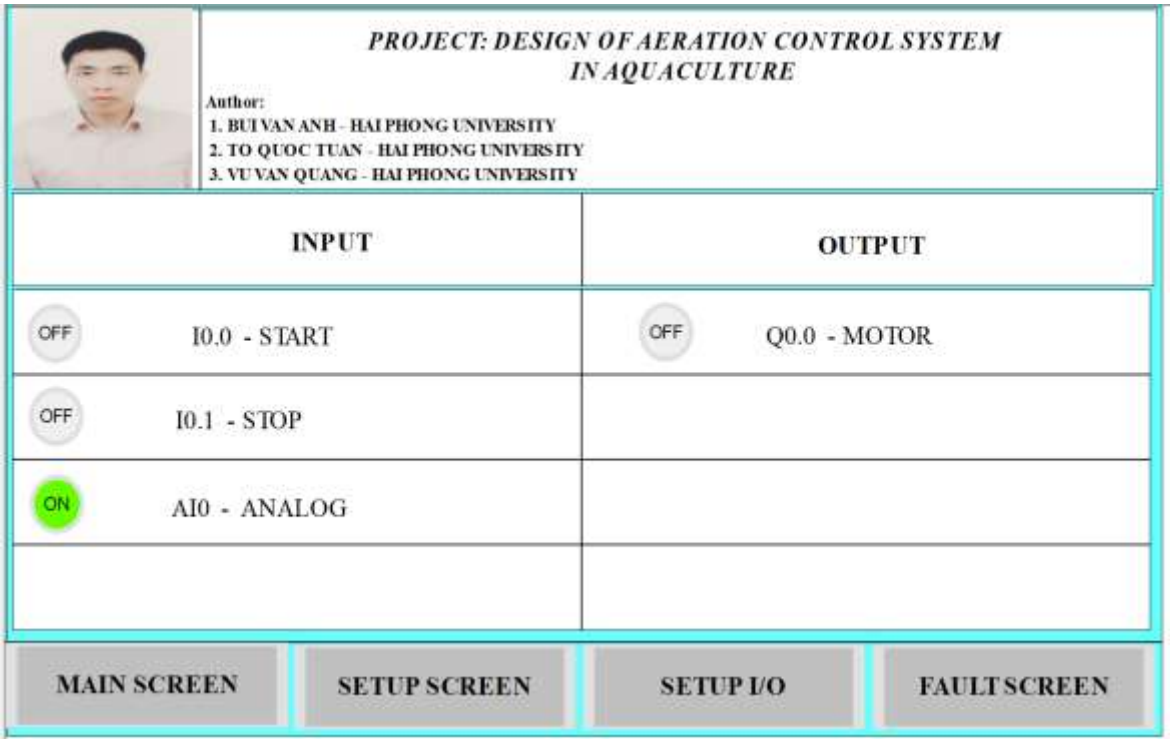

HMI SCREEN FOR INPUT AND OUTPUT SETTINGS

V. CONCLUSIONS

This article proposes a fully automatic system to control the aeration system in aquaculture to perform 24/7 monitoring to ensure the best conditions for the growth of farmed shrimp, helping to reduce costs. electricity and labor in the aquaculture process. Practical application brings many practical benefits to owners in terms of both value and brand to check and adjust technical parameters and evaluate the effectiveness of the project.

REFERENCES

[1]. Jensen, G. L., Bankston, J. D., & Jensen, J. W. (2004). Pond aeration: Types and uses of aeration equipment. Oklahoma Cooperative Extension Service.

[2]. Irawan, R., & Mubarok, M. A. (2023). Number of holes and blades to control the performance of aquaculture aerator. Aquaculture and Fisheries, 8(6), 672-680.

[3]. Tong, C., He, K., & Hu, H. (2024). Design and Application of New Aeration Device Based on Recirculating Aquaculture System. Applied Sciences, 14(8), 3401.

[4]. Boyd, C. E., & McNevin, A. A. (2021). Aerator energy use in shrimp farming and means for improvement. Journal of the World Aquaculture Society, 52(1), 6-29.

[5]. Roy, S. M., P, J., Machavaram, R., Pareek, C. M., & Mal, B. C. (2021). Diversified aeration facilities for effective aquaculture systems—a comprehensive review. Aquaculture International, 29, 1181-1217.

[6]. He, K., Tong, C., hang He, L., yu Liu, H., & yu Hu, H. (2023). Design and Testing of a New Type of Push-Water Aerator Device for Integrated Pond Aquaculture Systems.

[7]. Hossain, M. R. Design and Implementation of an Aerator Pumping system for Biofloc fish firming using 12V Battery with controller (Doctoral dissertation, Independent University, Bangladesh).

[8]. Juliyanto, M. A., Sulistiyowati, I., & Ahfas, A. (2023). Design of Turbine Aerator with Remote Control and Internet of Things (IoT)-Based Water pH Monitoring. Buletin Ilmiah Sarjana Teknik Elektro, 5(1), 156-166.

[9]. Roy, S. M., & Biswas, A. (2020). Application of aerator in aquaculture: a review. E-planet, 18(2), 185-188.

[10]. Rieder, C. J. (2023). Design Optimization of a Wind-Powered Aeration System for Enhancing Rural Aquaculture (Doctoral

dissertation, University of Toronto (Canada)).

[11]. Fauzi, A., Handoyo, W. T., Hakim, A. R., & Hidayat, F. (2021, November). Performance and Energy Consumption of Paddle Wheel Aerator Driven by Brushless DC Motor and AC Motor: A Preliminary Study. In IOPConference Series: Earth and Environmental Science (Vol. 934, No. 1, p. 012010). IOP Publishing.

[12]. Yatin, K., & Jaisin, C. (2022, November). Development of a tribrid power supply system for paddlewheel aeration of an aquaculture pond. In AIP Conference Proceedings (Vol. 2681, No. 1). AIP Publishing.