

Implementation of Raspberry Pi PICO as PLC for Monitoring and Control in Swiftlet Cultivation Based on Weintek HMI

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Article Information	ABSTRACT
Article History Received: December 05, 2024 Revised : December 30, 2024 Published: January 06, 2025	Swiftlet farming is one of the promising cultivation efforts for breeders because it can generate multiple and sustainable profits. Large profits will have an impact on the economy of the community, especially swiftlet breeders. The use of technology to provide ideal conditions for swiftlet farming will greatly affect the quality of the swiftlet nests. The use of technology in providing an ideal environment for swiftlet cages cannot be separated from a system that is designed and reliable in extreme conditions. Raspberry Pi Pico which has an ARM Cortex processor is one solution to the technology used. The implementation of Raspberry Pi Pico into a PLC is one alternative in the development of technology in swiftlet farming. The Raspberry Pi Pico PLC was chosen because it is cheap and has been proven to be reliable in the industrial world. Control of the swiftlet farming room with a room temperature of 25 - 27 °C and humidity of 80 - 90%. The LM35 sensor with ladder programming using raspberry pi pico compared to sensors on the market, namely the HTC-1 digital thermometer, has an error of 2.02%, and testing of the soil moisture sensor which has been tested with an error of 1.31%. HMI wientek can display temperature and humidity well and has industrial standard reliability that can be used nonstop 24 hours. The use of raspberry pi pico as a PLC has many advantages and is easy to use because it can use the Mitsubishi PLC program, namely GX Work2.
Keywords: <i>Raspberry Pi Pico;</i> <i>Swiftlet;</i> <i>Temperature;</i> <i>Soil Humidity;</i> <i>Weintek HMI.</i>	

INTRODUCTION

Swiftlet farming is one of the businesses in the cultivation sector that is quite promising for farmers because it can generate multiple and sustainable profits (Kha et al., 2021). This profit is obtained from the sale of swiftlet saliva or serang called swiftlet nests which have a high selling price which is influenced by the quality of the nest and market conditions, namely with the export selling price of the nest reaching IDR 15 million per kilogram (Budiawan et al., 2022).

Currently, Indonesia is one of the world's suppliers of swallow's nests. Countries in Asia, America, and Africa are the main destinations for swallow's nest exports from Indonesia. The country with the largest consumption of swallow's nests is China (Dewi et al., 2021). Collocalia fuciphaga is one type of swallow that is often found in Indonesia and this type of swallow is a producer of white swallow's nests and is most in demand by consumers (Rajani et al., 2021). Swallow's nests are rich in amino acids, minerals, and antioxidants, so they are often used as food and beverage products, medicinal ingredients, perfumes and beauty products (Uddin et al., 2023).

The price of swallow's nest has a high value because of its very high nutritional value, both for health and beauty, becoming a menu served in elite restaurants. The demand for this commodity is still very high, however, the high demand is not comparable to the level of production. This makes the swallow farming business still promising in the future.

The technology needed in swiftlet cultivation is to regulate the ideal environmental conditions for swiftlets, so that swiftlets can develop optimally and produce quality swiftlet nests. The more ideal the environmental conditions for swiftlets, the more the production of swiftlet nests will increase. The selection of technology used should have reliable and long-lasting performance, namely using PLC (Aziz et al., 2021). PLC (Programmable Logic Controller) used in swiftlet cultivation to regulate the provision of water in the swiftlet cultivation room environment to maintain the temperature and humidity of the residence to suit the needs of swiftlets to develop optimally, namely 25 - 27 °C and humidity 80 - 90% (Baco et al., 2023).

PLCs that have reliability in long-term and continuous work have a weakness, namely that they are expensive and difficult to afford for small home industry level entrepreneurs (Putri et al., 2021). Based on the weakness of the high price of the PLC, the use of Raspberry Pi Pico as a PLC is an alternative for use in swallow farming because it has a low price and can be programmed easily and reliably.

Raspberry Pi Pico is used as a PLC to control the room temperature and humidity where the swiftlets live. The LM 35 sensor is used to determine the temperature in the swiftlet cultivation room environment. LM 35 is used because it has an analog output that can be input from the Raspberry Pi Pico PLC. The soil moisture sensor is used to determine the humidity of the ground floor of the swiftlet cultivation room. If the humidity of the ground floor is high, it is certain that the humidity of the swiftlet cultivation room will also be high. Soil moisture is used because it has an analog output that is inserted into the sand media on the floor of the swiftlet room. Weintek HMI is used to display the monitored and controlled temperature and humidity values. Weintek HMI which has industry standard reliability at an affordable price will facilitate monitoring of the conditions of the swiftlet cultivation room (Uddin et al., 2023).

RESEARCH METHODS

The following research method contains hardware and software planning and system requirements analysis in the development of research tools or systems. The use of raspberry pi pico as PLC and HMI as a temperature and humidity data display that can work 24 hours non-stop due to industry standards.

System Design

This study uses a PLC from a raspberry pi pico filled with PLC firmware. The PLC is tasked with controlling and monitoring the temperature and humidity in the swiftlet breeding house. The communication protocol between the Weintek HMI and the PLC used is the MODBUS protocol with RTU (Remote Terminal Unit) mode. Temperature and humidity data will be displayed on the Weintek HMI. Control and monitoring can be done on the Weintek HMI either automatically or manually.

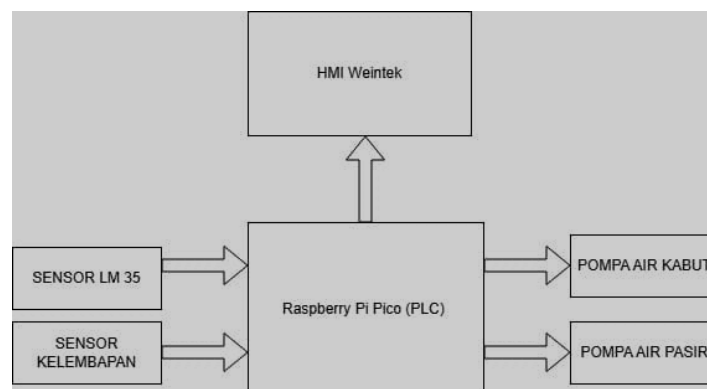


Figure 1. Block diagram of the system being designed

Hardware Design

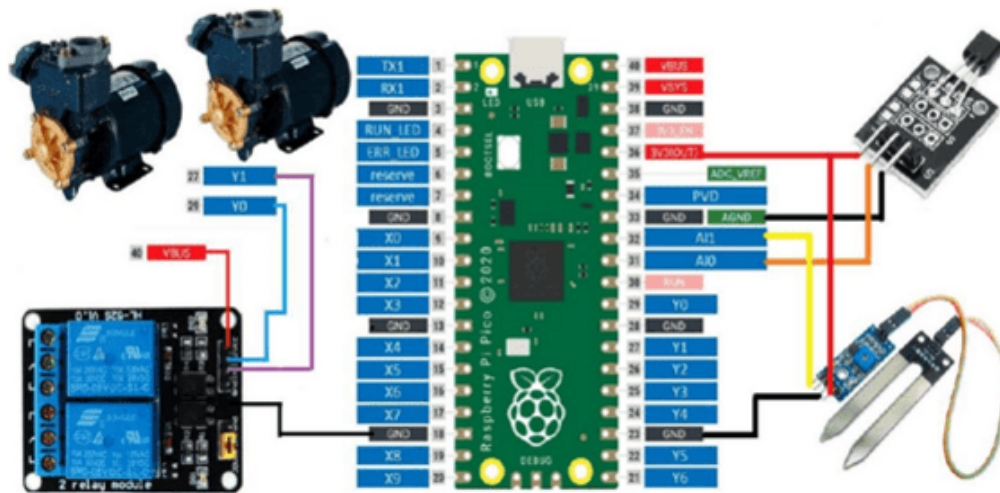


Figure 2. PLC hardware design

In the study entitled the implementation of Raspberry Pi Pico as a PLC for monitoring and control in swiftlet farming based on HMI Weintek, several hardware are used. The hardware used includes Raspberry Pi Pico as a PLC, RS 485 to TTL as a serial bridge between PLC and HMI, LM 35 sensor as a temperature sensor, soil moisture sensor, relay as a switch for 220 AC load and HMI Weintek as a display for the designed system. Figure 2 explains that the designed system has two inputs in the form of a temperature sensor (LM 35) and a soil moisture sensor and an output in the form of a relay as a switch for 2 water pumps. The LM 35 sensor functions to determine the temperature of the swiftlet farming room and the humidity sensor is tasked with determining the humidity of the sand on the floor of the swiftlet farming room. The relay functions as a water pump switch for fog and a water pump to irrigate the sand on the ground floor of the swiftlet farming room. Figure 3 shows the RS 485 connection to the Weintek HMI from the Raspberry Pi Pico PLC. The use of RS 485, which is an industry standard that is strong against noise, was chosen in the designed system.

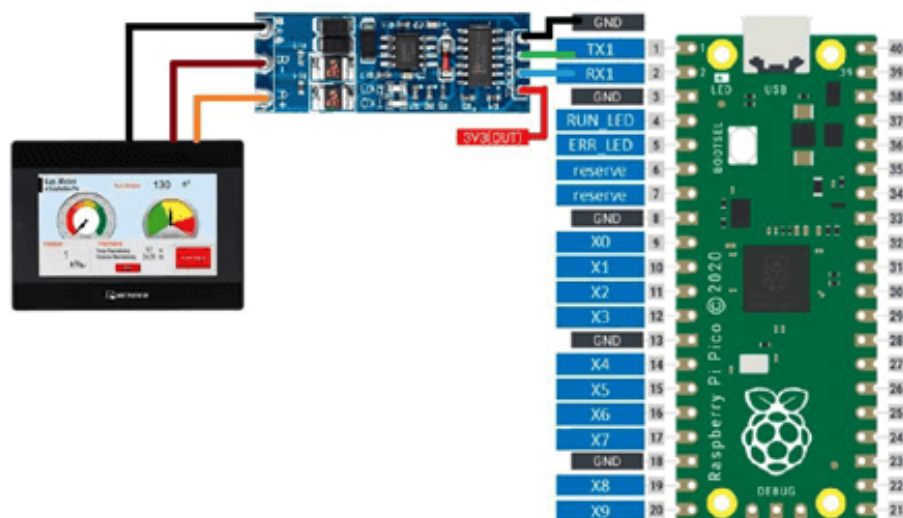


Figure 3. PLC hardware design with Weintek HMI

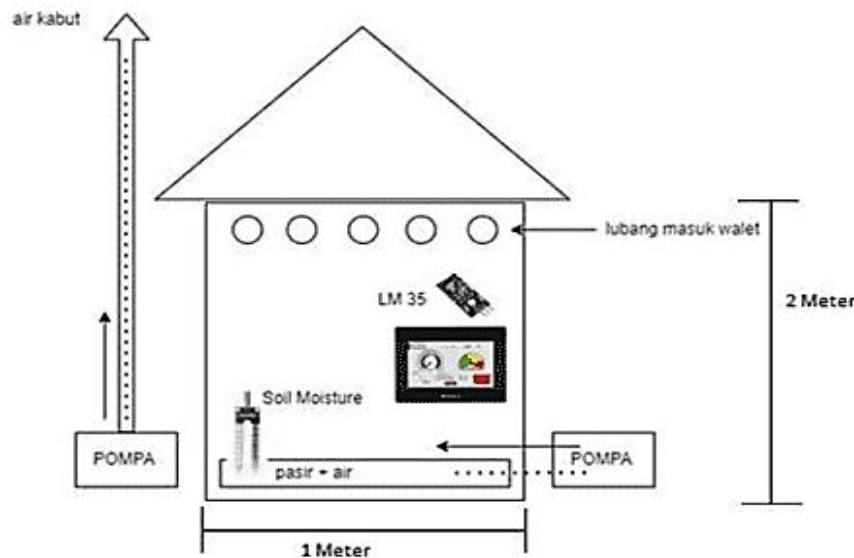


Figure 4. HMI and Sensor Placement Design

From Figure 4, the placement of sensors and HMI that will be implemented in the designed system is shown. The Raspberry Pi Pico PLC has 2 analog input channels with analog voltage as its input and with an ADC resolution of 8 bits with a maximum value of 255. The two channels are A.0 and A.1 which are on the Raspberry Pi Pico Pin 31 and Pin 32. In this study, the LM 35 temperature sensor is inserted into the Raspberry Pi Pico pin at pin 31 and the soil moisture sensor is inserted into pin 32. The output is Y0 (pin29) and Y1 (pin 27) from the Raspberry Pi Pico which will provide a control signal to the relay to activate the mist water pump and sand water pump to provide the desired temperature and humidity, namely a temperature of 25 - 27 °C and humidity of 80 - 90%.

HMI Display Design

In this study, software design begins with Raspberry Pi Pico PLC programming and communication between PLC and HMI with MODBUS protocol. Raspberry Pi Pico PLC programming uses GXWork2 owned by Mitsubishi PLC. The appearance of Weintek HMI that will be designed is as shown in Figure 5.

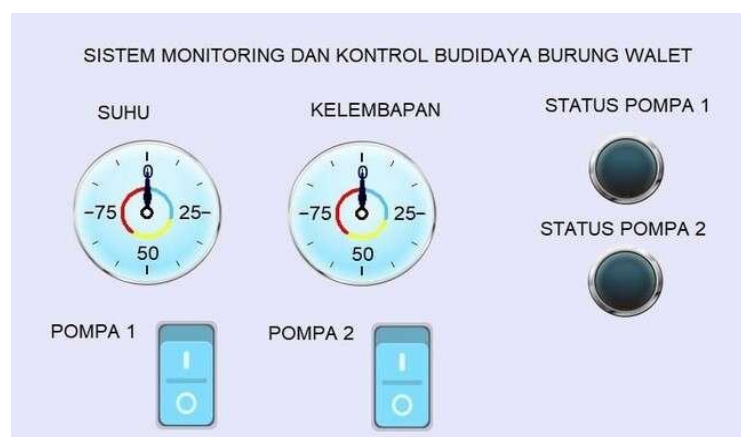


Figure 5. Software design on Weintek HMI

System Work Process

In the study entitled the implementation of Raspberry Pi Pico as a PLC for monitoring and control of swiftlet farming based on HMI Weintek has a work system flowchart as shown in Figure

6. Figure 6 explains that first of all the raspberry pi pico as a PLC will take data from two sensors, namely LM35 as a temperature sensor and a humidity sensor to detect the humidity of the sand under the swiftlet farming room. Then the results will be displayed on the Weintek HMI. If the temperature is more than 27°C then water pump 1 will turn on to create mist water around the swiftlet cultivation area so that the temperature around the swiftlet cultivation area is suitable for swiftlet development, which is below 27°C. Likewise, the humidity in the swiftlet cultivation room if it is less than 80% then water pump 2 will turn on to irrigate the water in the sand below the swiftlet cultivation room.

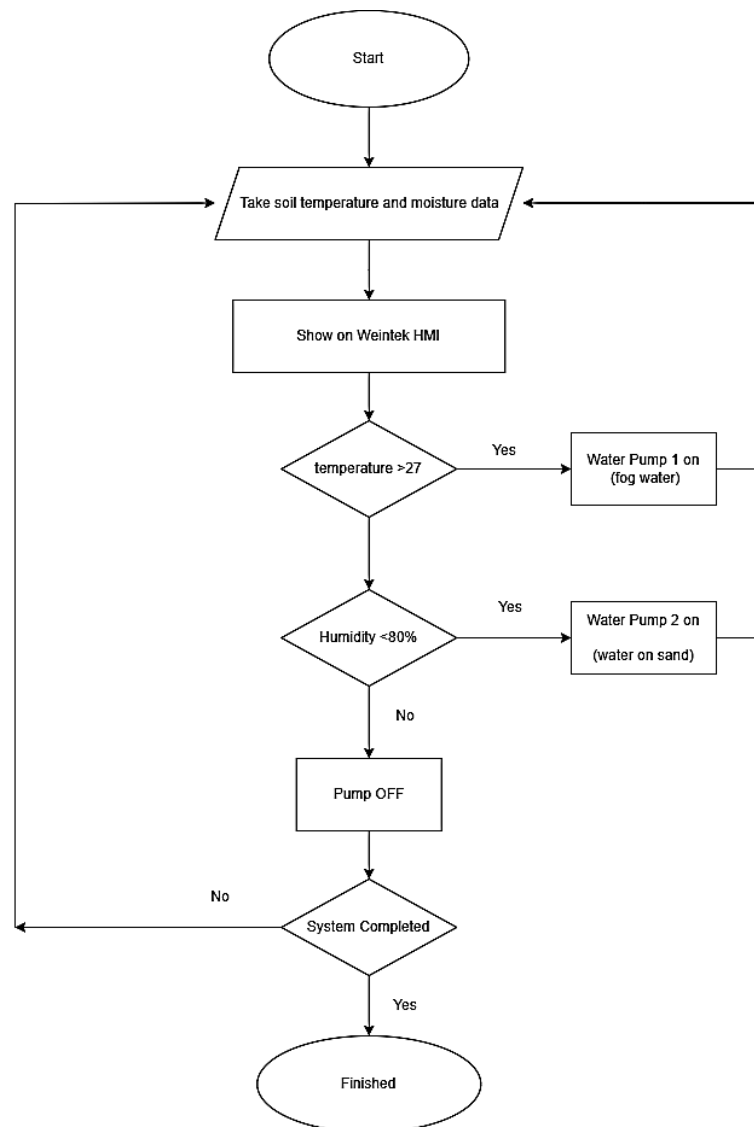


Figure 6. System Work Process

RESULTS AND DISCUSSION

After designing the system, the next step is to test the system that has been created. The implementation of Raspberry Pi Pico as a PLC for monitoring and control in swallow farming based on HMI Weintek carried out initial testing on the LM 35 temperature sensor by comparing it with a sensor available on the market, namely the HTC-1 digital thermometer. The next test is the soil or sand moisture sensor which is compared with the SM 150T soil moisture available on the market. This test aims to see the differences and percentage of errors between sensors designed using the Raspberry Pi Pico PLC program and sensors that are already on the market. Then testing was carried out on the entire system with two sensors and two pumps. Testing the Weintek HMI

display was carried out by looking at the response of the temperature and sand humidity sensors that were monitored and controlled from the HMI.

LM 35 sensor testing

This test was conducted to calibrate the LM 35 sensor programmed with PLC with HTC-1 digital thermometer available in the market. The test results can be seen in table 1. Table 1 shows that the average error of the LM 35 test programmed with PLC against HTC-1 is 2.02 % with the number of data tests as many as 10 times so that the LM 35 in the designed system is appropriate and can be used as a temperature sensor to monitor the temperature in the swiftlet farm.

Table 1. Test results of the LM 35 sensor with the HTC-1

No	LM 35 (°C)	HTC-1 (°C)	% error
1	28	27	3,5 %
2	25	25	0 %
3	26	25	3,8 %
4	30	30	0 %
5	29	28	3,4 %
6	28	28	0 %
7	31	30	3,22 %
8	33	32	3,03 %
9	30	29	3,33 %
10	31	31	0 %
% average error			2,02 %

Soil Moisture Testing

For the next test is the humidity sensor that will be compared with the soil or sand humidity sensor on the market, namely SM150T. Table 2 is the result of testing the soil or sand humidity sensor programmed with PLC with SM150T with a total of 10 data tests. From table 2 it can be concluded that the average difference in error between the soil humidity used in the system with SM150T has an error of 1.32 %.

Table 2. Soil Moisture sensor test results with SM150T

No	Soil Moisture (RH)	SM150T (RH)	% error
1	65	64	1,53 %
2	70	68	2,85 %
3	76	75	1,31 %
4	80	80	0 %
5	75	74	1,33 %
6	87	85	2,29 %
7	85	84	1,17 %
8	75	74	1,33 %
9	88	88	0 %
10	73	72	1,36 %
% average error			1,32 %

Raspberry Pi Pico PLC communication testing with Weintek HMI

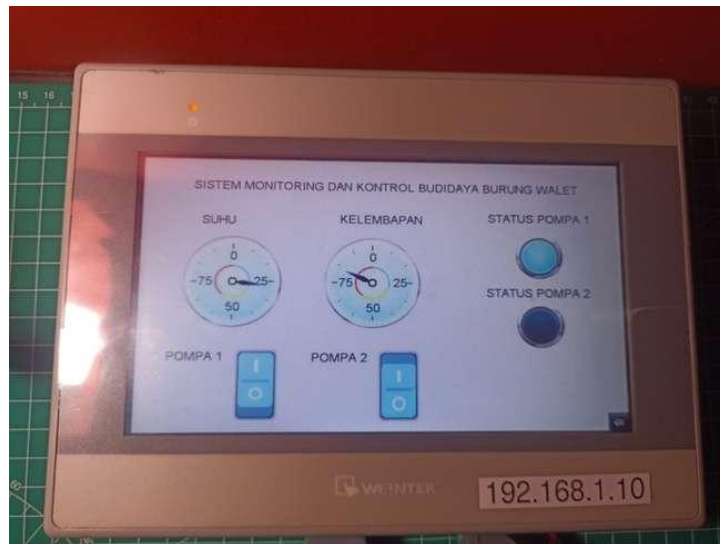


Figure 7. Weintek HMI display

HMI testing is carried out to determine the display response of the monitoring system from the soil moisture sensor and sensor. Testing is carried out by looking at the response to changes in temperature and humidity sensor data and manual on-off control to turn on two pumps. Weintek HMI has provided information in the form of temperature and humidity data so that swallow farmers can find out the temperature and humidity of sand or soil. In addition, farmers can control it manually via HMI.

Testing Raspberry Pi PICO as PLC

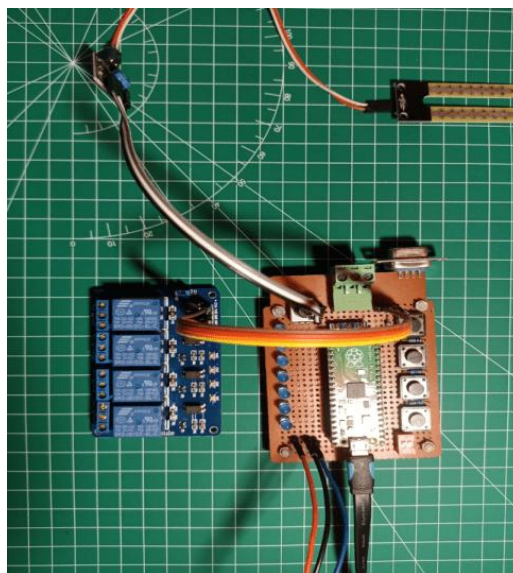


Figure 8. Raspberry Pi Pico hardware as PLC

Raspberry pi pico testing as a PLC is done to find out whether raspberry pi pico can be programmed with ladder or not. The next test is the use of arithmetic program with ladder for signal conditioning from the sensor to match or approach the sensor sold on the market. The use of mitsubishi plc firmware on raspberry pi pico is expected to make it easier for PLC users to program ladder with GX Work2 software. In this test, the use of raspberry pi pico as a PLC can be said to be smooth without any significant obstacles.

Testing with the whole system



Figure 9. Overall system testing

The overall system testing was conducted to determine whether the system was working properly and according to plan. Table 4 shows the results of the overall system testing. Temperatures above 28°C will activate the mist water pump and will turn off if below 28°C, as will the humidity of the sand in the swiftlet farm. If the humidity in the swiftlet farm building is less than 80%, the water pump that irrigates the sand will be activated.

Table 4. Overall system testing

No	LM35	Soil Moisture	water pump 1	water pump 2
1	28	88	not active	not active
2	30	60	active	active
3	29	70	active	active
4	25	75	not active	active
5	29	82	active	not active
6	32	60	active	active
7	35	78	active	active
8	31	82	active	not active
9	25	80	not active	not active
10	34	74	active	active

CONCLUSION

From several tests conducted, it can be concluded that the LM35 sensor with ladder programming using the raspberry pi pico compared to sensors on the market, namely the HTC-1 digital thermometer, has an error of 2.02%. It can be concluded that the LM 35 sensor can be used on the raspberry pi pico PLC as well as the soil moisture sensor or which has been tested with an error of 1.31%. The wientek HMI can display temperature and humidity well and has industry standard reliability that can be used non-stop 24 hours. The use of the raspberry pi pico as a PLC has great advantages and is easy to use because it can use the Mitsubishi PLC program, namely GX Work2.

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