Automatic Dam Gate Monitoring System with Outseal Mega V2 PLC and Haiwell HMI

Ahmad Nur Rofix, Alfian Ma'arif
Department of Electrical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia

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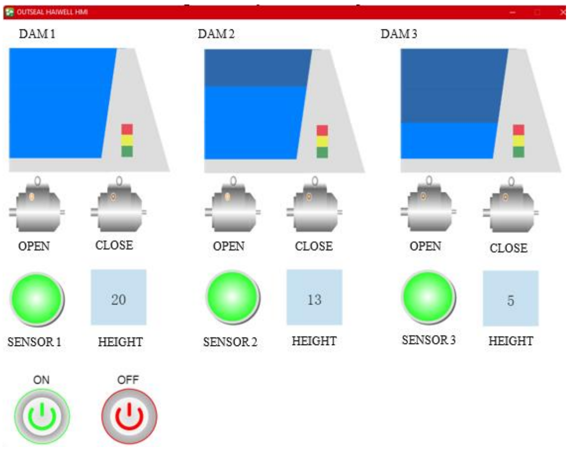
Corresponding Author:

Alfian Ma'arif,
Department of Electrical Engineering,
Universitas Ahmad Dahlan,
Yogyakarta, Indonesia.
Email:
alfianmaarif@ee.uad.ac.id

ABSTRACT



Dam is a building used by humans as a regulator of water discharge in a river. In the tropics the big role of dams occurs throughout the year. The active role of dams in life is to store water reserves in the summer, as well as reduce the risk of flooding that occurs during the rainy season. This research discusses the process of monitoring a dam using the Outseal Mega V2 PLC as a control device for the entire system supported by an analog module as an analog value reading device (ADC). The ADC value will be obtained through the output voltage from the potentiometer which is used instead of the water level sensor. The ADC value will then be processed by the PLC to make a decision. This research is supported by an HMI interface using Haiwell Cloud Scada Develop software so that machine-human communication can be carried out and real-time monitoring is achieved.

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1. INTRODUCTION

Indonesia is a country with a tropical climate. The physiographical conditions of Indonesia's territory, such as latitude, altitude, wind patterns (trade winds and monsoon winds) make Indonesia one of the countries with moderate to high rainfall at the peak of the rainy season.

As a developing country with a population of 267 million people, Indonesia has many big cities which often flood [1] when the rainy season comes. From the data presented by CCN Indonesia, in 2016 it was recorded that 2,342 areas in Indonesia experienced flooding. This number increased by 35% when compared to the number of flood disasters in 2015 with the most flood locations, namely in urban areas and downstream rivers [2].

Many countries use dams or dams as a regulator of water [3] discharge so that during the rainy season the volume of water can be controlled to reduce the risk of flooding [4]. Dams or dams are a construction to hold back the flow of water so that there is no excess volume of water distribution to tributaries [5]. The way the dam works is to collect water from various sources/rivers in a place resembling a large tub with doors on several sides [6]. The door which will later be used to regulate the amount of water that will be distributed to the small rivers below. More utilization of dams can be used as hydropower, recreational facilities, and ponds [7].

In Indonesia itself, dams have been used as a regulator of water discharge and water reserve facilities for irrigating rice fields. However, there are still many dams that operate manually, namely the control of the dam door still depends on human power so that the monitoring system on the dam cannot be 24 hours so that when there is heavy rain there can be an excess of water volume resulting in flooding [8]. From the problems above, we need a tool that can be used to measure the water level and open the dam's sluice gate gradually so that excessive water discharge does not occur so that flooding can occur. The control system used in the tool is the Programmable Logic Controller (PLC) [9] and the Human Machine Interface (HMI) [10] as the controller and visual monitoring of the water level in the dam.

2. METHODS

This research took place at Universitas Ahmad Dahlan, Yogyakarta. This research is based on several problems, especially controlling the yield of rainwater in dams. With proficiency in electrical engineering studies, this research was carried out using the Outseal PLC [11] as a tool resulting from the development of industrial automation technology [12]. Using the analogy of dams with different structures in one river flow path.

In this study, the system workflow created was when the device was turned on, the sensor would read the value of the water level. After the sensor reads the water level, it will then be calculated by the PLC. When the PLC calculates that the water value exceeds the specified limit, the PLC will make the decision to turn on the electric motor to open the dam door [13]. With the working method that has been described, a system flowchart can be made as shown in Figure 1.

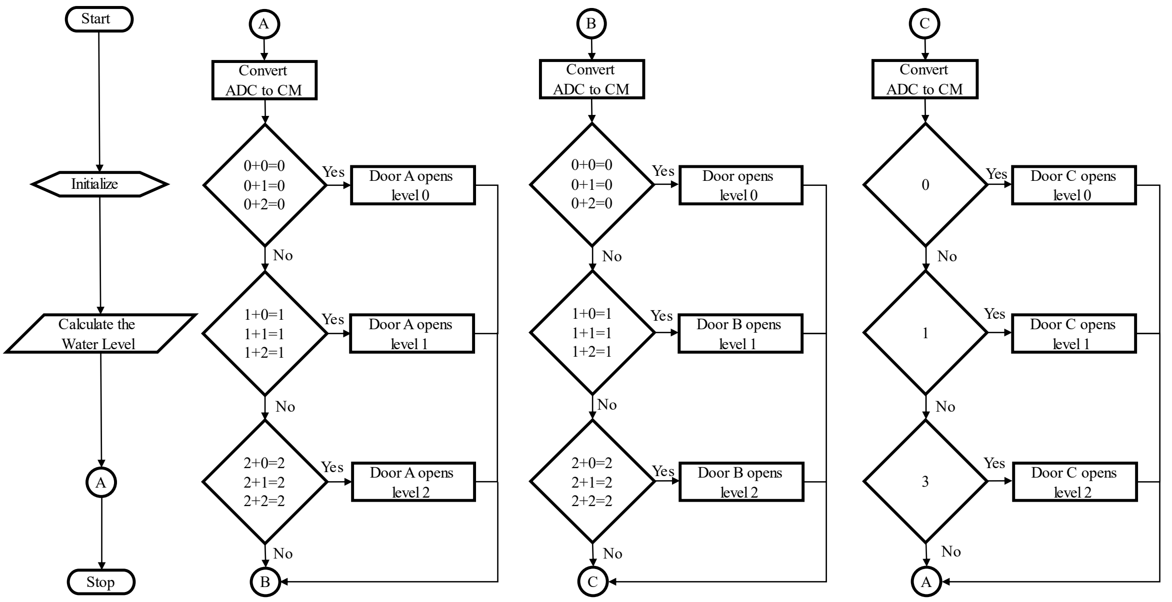

Figure 1. System Flowchart

With the flowchart that has been made, it can be described briefly in the form of a block diagram. For a block diagram arranged like Figure 2.

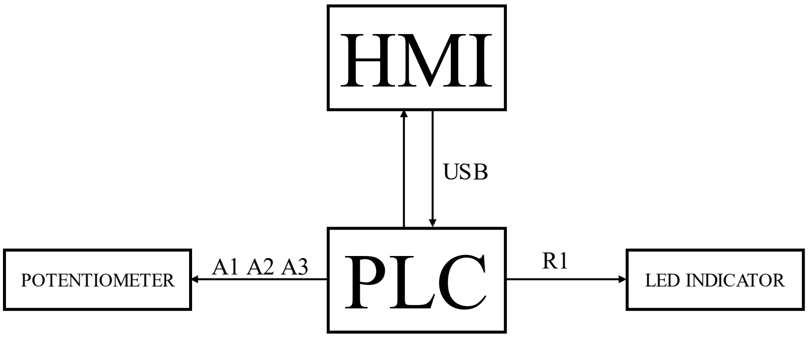

Figure 2. System block diagram

With reference to the flowcharts and block diagrams that have been prepared, it can be concluded that the workflow of the system built in this study can be seen in Figure 3.

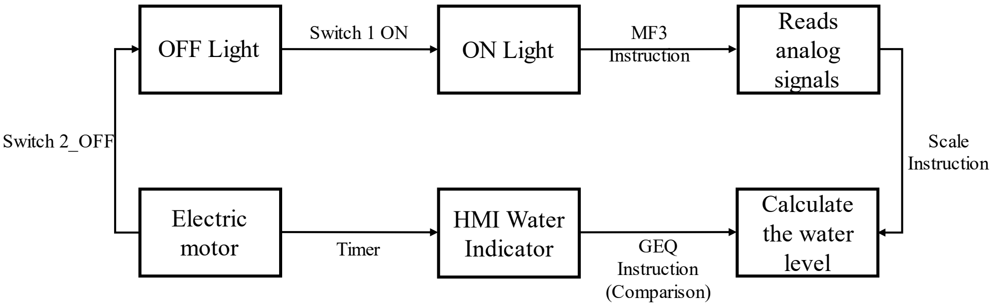

Figure 3. State Diagram

In this study the materials used included PLC Outseal, LED lights, potentiometers, and two buttons for start and stop. The wiring of all materials used can be seen in Figure 4.

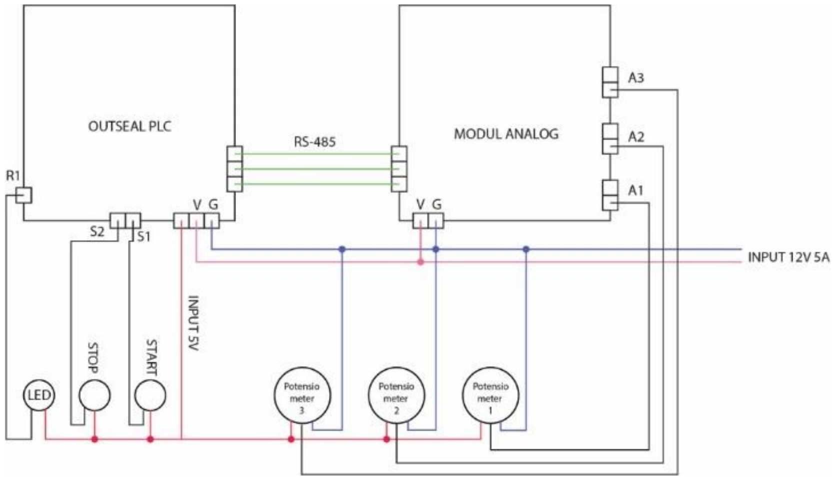

Figure 4. Wiring Diagram

3. RESULT AND DISCUSSION

After conducting research, the results obtained from various tests were obtained. The first stage is system testing. System testing aims to find out by simulation whether the system is running as expected or not. In system testing, things that were observed included Outseal PLC connections with analog modules with MF3 functions, scale functions, timer functions, GEQ or comparison functions and HMI [14]. The results of system testing can be seen in Figure 5, Figure 6, Figure 7, Figure 8, and Figure 9.

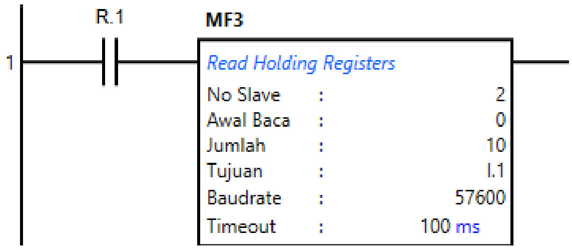

Figure 5. MF3 function

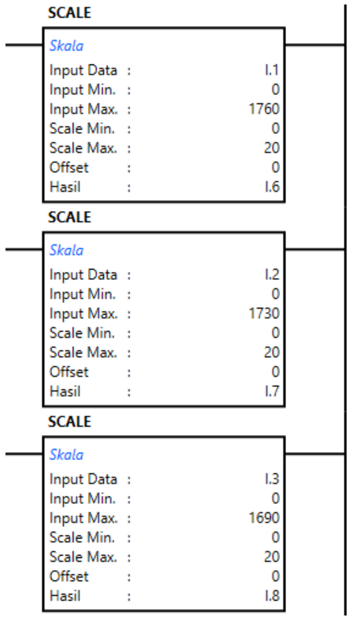

Figure 6. Scale Function

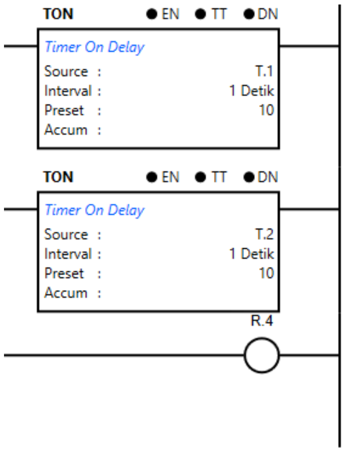

Figure 7. Timer function

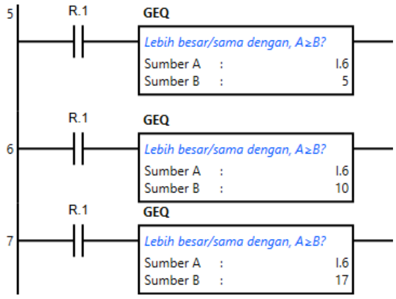

Figure 8. GEQ function or comparison

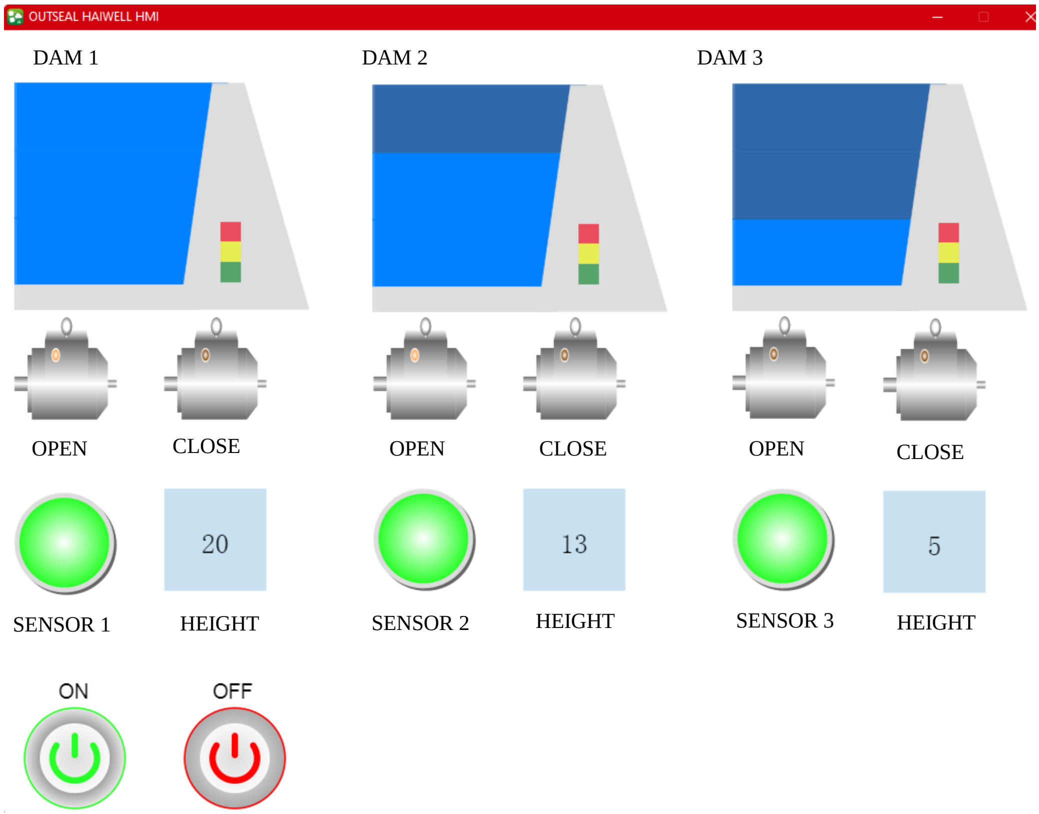

Figure 9. HMI System

The next test is to measure the value of the input voltage and the value of the voltage on the potentiometer. This measurement is carried out using a multimeter as a supporting device [15]. The results of the measurements can be seen in Table 1.

Table 1. System voltage testing

	Input Voltage(V)	ADC input Voltage (V)	ADC Voltage (V)
Input	4.6		
Potentio minimum value 1	0	0	0
Potentio maximum value 1	4.59	1.45	1760
Potentio minimum value 2	0	0	0
Potentio maximum value 2	4.56	1.43	1737
Potentio minimum value 3	0	0	0
Potentio maximum value 3	4.46	1.4	1696

After testing the voltage on the tool, then taking data samples on each potential [16]. Sampling as much as 10 times the sample with a height of 2 meters. In taking the sample data [17] [18], the measurement values obtained from the PLC analog data are shown in Table 2, Table 3, and Table 4.

Table 2. Potentio sample 1

No.	Height	ADC Value (decimal)	Rated Voltage (V)
1	2	190	0.19
2	4	416	0.37
3	6	590	0.51
4	8	789	0.67
5	10	892	0.75
6	12	1140	0.95
7	14	1225	1.04
8	16	1446	1.2
9	18	1647	1.36
10	20	1761	1.45

Table 3. Potentio sample 2

No.	Height	ADC Value (decimal)	Rated Voltage (V)
1	2	195	0.2
2	4	412	0.37
3	6	555	0.48
4	8	774	0.64
5	10	941	0.79
6	12	1071	0.9
7	14	1241	1.03
8	16	1393	1.15
9	18	1577	1.3
10	20	1732	1.43

Table 4. Potentio sample 3

No.	Height	ADC Value (decimal)	Rated Voltage (V)
1	2	192	0.19
2	4	388	0.35
3	6	531	0.46
4	8	703	0.6
5	10	912	0.77
6	12	1054	0.88
7	14	1200	1
8	16	1389	1.15
9	18	1563	1.29
10	20	1698	1.4

The next test is the calculation of the readable ADC value. To calculate the readable ADC value, use Equation (1).

$$Dx = \frac{Vy\,reff}{Dx\,reff} \times \frac{Vy}{x} \tag{1}$$

Explanation:
Vy is the rated input voltage, Dx is the calculated digital value, $Vy\,reff$ is input voltage reference, and $Dx\,reff$ is the maximum digital value.
With Equation (1), the calculation results are obtained which can be seen in Table 5, Table 6 and Table 7.

Table 5. Potential Calculation Results 1

No.	Height	Rated Voltage(V)	Rated ADC Value
1	2	0.19	235.7727
2	4	0.37	459.1364
3	6	0.51	632.8636
4	8	0.67	831.4091
5	10	0.75	930.6818
6	12	0.95	1178.864
7	14	104	1290.545
8	16	1.2	1489.091
9	18	1.36	1687.636
10	20	1.45	1799.318

Table 6. Potential Calculation Results 2

No.	Height	Rated Voltage(V)	Rated ADC Value
1	2	0.2	248.1818
2	4	0.37	459.1364
3	6	0.48	595.6364
4	8	0.64	794.1818
5	10	0.79	980.3182
6	12	0.9	1116.818
7	14	1.03	1278.136
8	16	1.15	1427.045
9	18	1.3	1613.182
10	20	1.43	1774.5

Table 7. Potential Calculation Results 3

No.	Height	Rated Voltage(V)	Rated ADC Value
1	2	0.19	235.7727
2	4	0.35	434.3182
3	6	0.46	570.8182
4	8	0.6	744.5455
5	10	0.77	955.5
6	12	0.88	1092
7	14	1	1240.909
8	16	1.15	1427.045
9	18	1.29	1600.773
10	20	1.4	1737.273

The final test is accuracy testing. Accuracy testing aims to determine the accurate level of ADC readings by measuring using a multimeter measuring instrument. In this accuracy test, equations and calculations of the values measured on the PLC [19] [20] are used using the voltage value as a reference for measuring analog data. Calculation of accuracy using Equation (2).

$$Accuracy = \frac{Measurement\ Value - Calculation\ Value}{Measurement\ Value} \times 100\% \quad (2)$$

With the values obtained from formula (2), the final comparison results are obtained in Table 8, Table 9, and Table 10.

Table 8. Potential comparison results 1

No.	Height	ADC reading	Measurement	Accuracy (%)
1	2	190	235	75.9
2	4	416	459	89.6
3	6	590	632	92.7
4	8	789	831	64.6
5	10	892	930	95.6
6	12	1140	1178	96.5
7	14	1225	1290	94.6
8	16	1446	1489	97
9	18	1647	1687	97.5
10	20	1761	1779	97.8

Table 9. Potential comparison results 2

No.	Height	ADC reading	Measurement	Accuracy (%)
1	2	190	248	72.7
2	4	416	459	88.5
3	6	590	595	92.6
4	8	789	794	97.4
5	10	892	980	95.8
6	12	1140	1116	95.7
7	14	122	1278	97
8	16	1446	1427	97.5
9	18	1647	1613	97.7
10	20	1761	1774	97.5

Table 10. Potential comparison results 3

No.	Height	ADC reading	Measurement	Accuracy (%)
1	2	190	235	77,2
2	4	416	434	88
3	6	590	570	92,5
4	8	789	744	94
5	10	892	955	95,2
6	12	1140	1092	96,3
7	14	1225	1240	96,5
8	16	1446	1427	97,2
9	18	1647	1600	97,5
10	20	1761	1737	97,6

To find out the average accuracy of each potentiometer, Equation (3) is used.

$$Average\ Accuracy = \frac{total\ measurement\ accuracy}{number\ of\ measurements} \tag{3}$$

The results of calculating the average accuracy on each potentiometer can be seen in Table 11.

Table 11. Accuracy of Each Potentiometer

No.	Each Potentiometer	Accuracy
1	Potentiometer 1	93.21%
2	Potentiometer 2	93.27%
3	Potentiometer 3	93.26%

4. CONCLUSIONS

From a series of stages in this study, it can be concluded that; Each potentiometer has a different minimum resistance value. The input voltage value and the output voltage value on the potentiometer have a difference of ± 1%. The smallest ADC accuracy value is 72% and the highest accuracy value is 97%. At a rated voltage of 0.7 Volt -1.4 Volt has an accuracy value exceeding 90%. The average value of ADC reading accuracy by measurement is 93%.

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