RESEARCH ARTICLE OPEN ACCESS

Design of the Water Balance System in the Water Tank

Toan Pham Van
Faculty of Mechanical Engineering and Technology, Ho Chi Minh City University of Food Industry (HUFI), 140 Le Trong Tan St., Tay Thanh Ward, Tan Phu Dist., Ho Chi Minh City 760310, Vietnam

ABSTRACT
The paper presents the implementation of the automatic water leveling system, which can be applied in related companies in food, chemical, and water treatment. The testing system includes standard equipment in industry such as a three-phase motor, ultrasonic level sensor, and Siemens S7-1200 PLC controller. The water level in the tank, is balanced control based on the PID controller, which automatically detects the optimal parameters for the real system. Experimental results highlight that the system operates stably and accurately. Thus, the implemented water balance system has a hight applicability in the practice.
Keywords: PID controller; water balance systems; Siemens S7-1200.

Date of Submission: 29-08-2020 Date of Acceptance: 14-09-2020

I. INTRODUCTION

The issue of management of liquids such as water, oil, gasoline, sewage as well as how to make efficiency is a matter of many people and organizations interested in the current era. The topics on design of water balance system in water tank are very interesting and attracts many technician, practitioners, and engineers. These systems are applied extensively in the fields of industry such as agriculture, chemistry, and civil engineering. In particular, in many companies, enterprises and factories, the water balance system has been playing an important role in monitoring and justifying the fluid in many various applications.

There are many methods to monitor and manage liquids, including manual methods and automatic control techniques. Nowadays, the method of liquid monitoring and management has been completely automated to reduce human labor and increase the productivity as well as flexibility in many enterprises.

To control and monitor the water level in the tank, the most efficient implementation method is ultilization of the PID controller. Understanding and implementing the PID controller is difficult because the actual systems are hard to do with the standards that we have previously calculated. Detection of the PID parameters for systems of the same type but varies in size, device parameters are also difficult and need skillful men in this regard. This study provides standardized steps to help readers in building the PID levels of water balance in the tank easily.

Method of implementing the hardware system
The block diagram and hardware design of the system is shown in Figures 1 and 2.

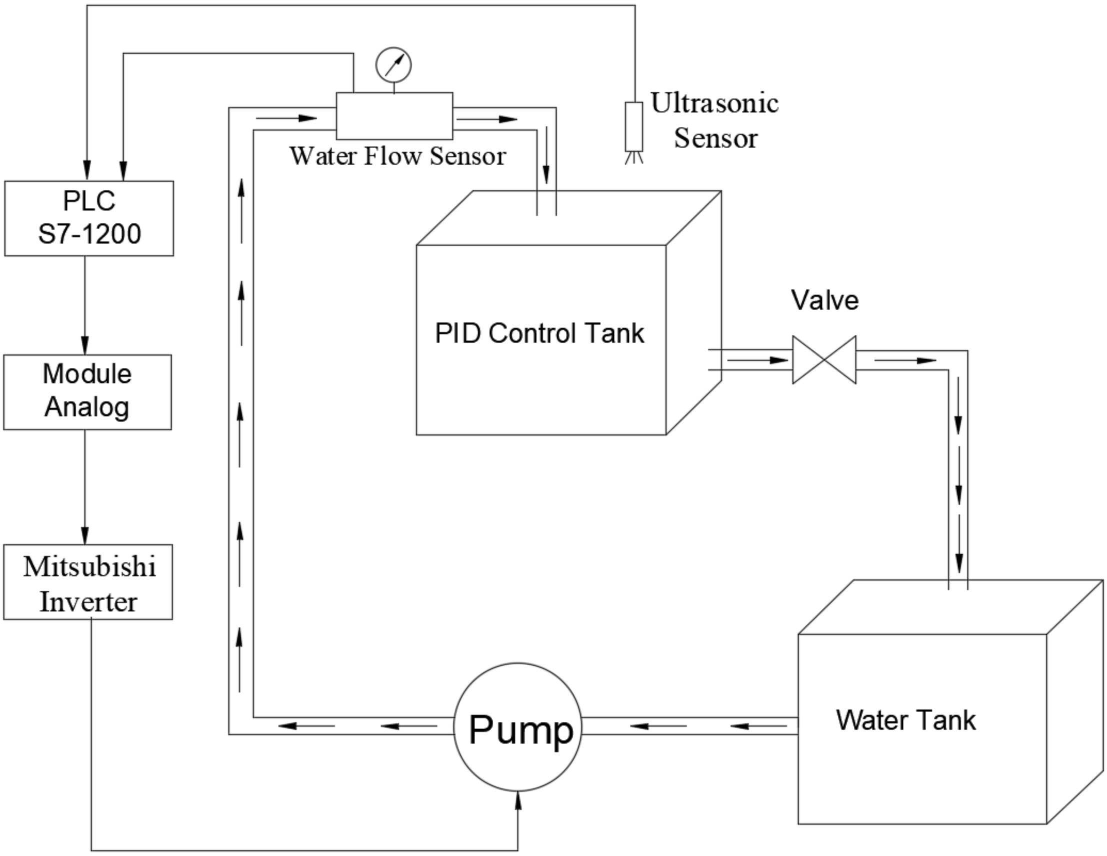


Figure 1: System block diagram

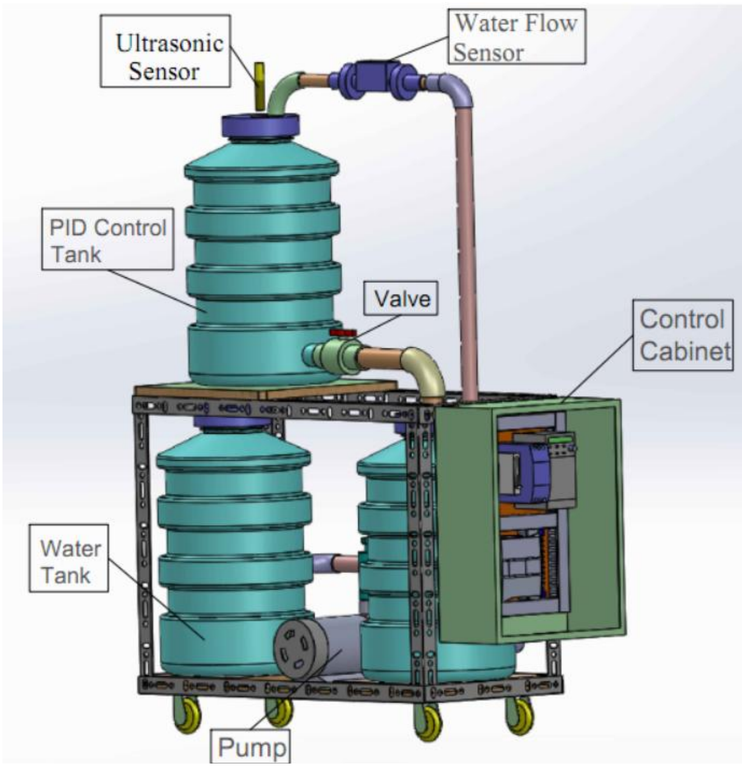


Figure 2: System hardware design

ISSN: 2248-9622, Vol. 10, Issue 9, (Series-III) September 2020, pp. 43-50

Part model frame: the model frame is designed compact. The entire frame is made from iron shaped V makes the system strong and easy to execute. Below are four wheels that make it easy to move the system on the ground or the workshop floor.

Water tank system: It consists of 20 liter bottles in clear form and can observe the water level in the bottle. Several computation of determining the tank is based on [2].

Ultrasonic sensor: Measuring distance from 3 to 30 cm, voltage output as 0 - 10V

Water flow sensor: Measuring range from 0 to 60 liters / minute, voltage output as 0 - 10V.

Water pump motor: 3 phase 220V motor type, capacity 200W, maximum flow 60 liters / minute

Mitsubishi inverter: Capacity of 200W, controlling motor of water pump motor

Central controller: S7-1200 PLC controller plays the role of controller with the following functions:

- Receive Analog signals from the sensor to determine the water level in the control tank and the water flow after passing through the pump
- Calculate PID values and output signals to Analog output module to control the inverter changing the water pump flow.

Design of the control program

PLC hardware configuration

With the above hardware proposal, we configure the PLC [1] with analog voltage input and output function (Figures 3 and 4).

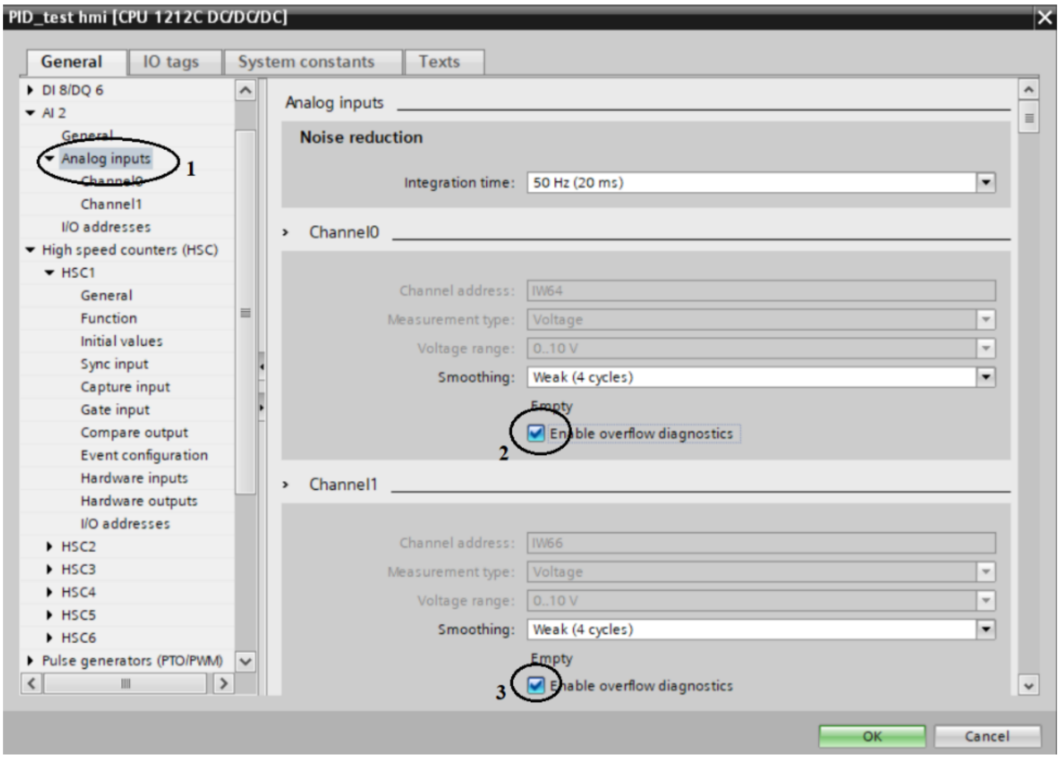


Figure 1: *Configure PLC to receive analog voltage values*

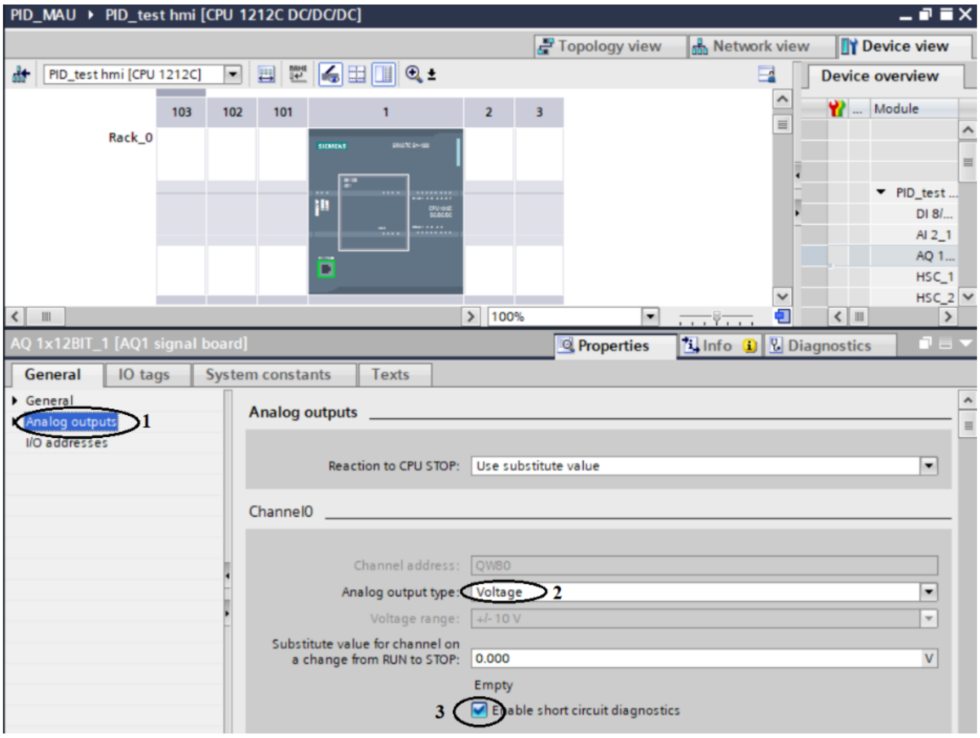


Figure 2: *Configure the analog board on the PLC as voltage output*

PID set configuration

Configure PID set on PLC S7-1200 Compact (as shown in Figures 5 and 6)

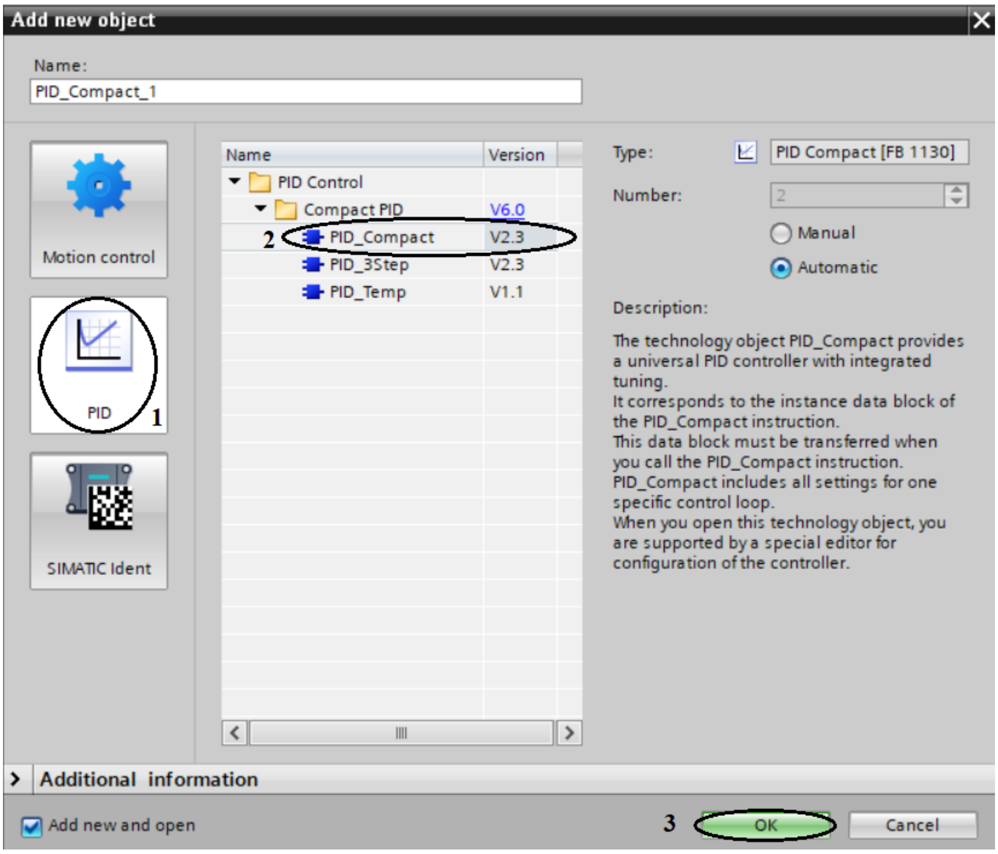


Figure 3: *Set of control object parameters for the PID*

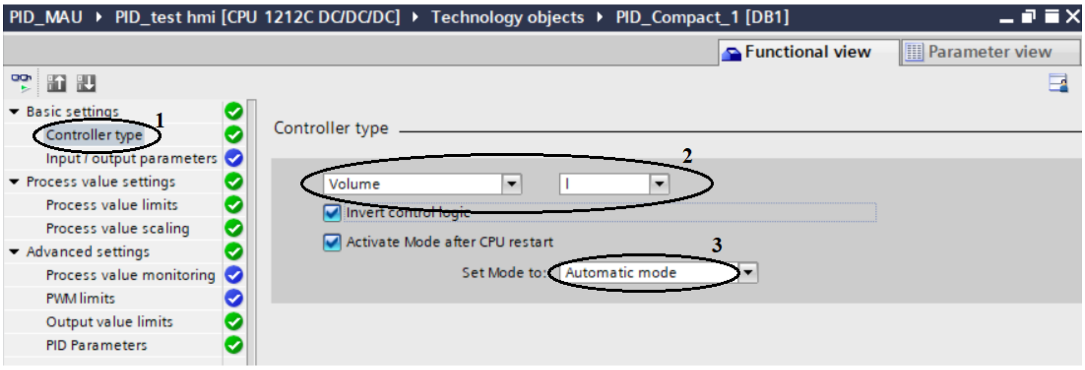


Figure 6: Basic settings of controller type

Select the control object, because the water level control, we select the control object is the volume (Volume) in units of liters (l), the parameter detection mode is automatic (Automatic mode)

Control signal setting

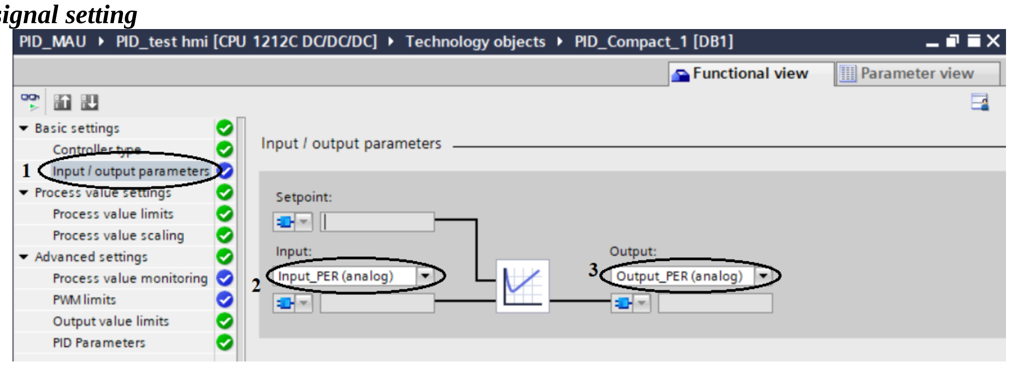


Figure 7: Control signal setting

Set the controller input signal to Analog and the output signal after the signal processing is Analog (Figure 7).

Set the PID set input limits

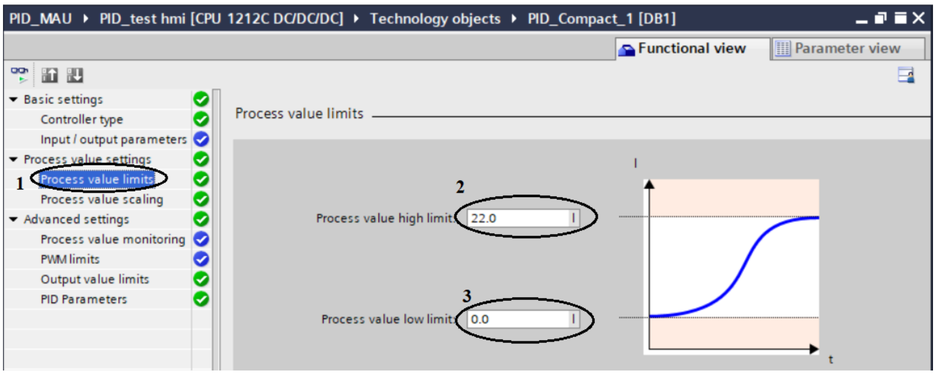


Figure 8: Process value limits

With the recommended hardware of 20 liters, we set the maximum water level to 22 liters and the smallest to 0 liters (Figure 8).

Set the volume ratio

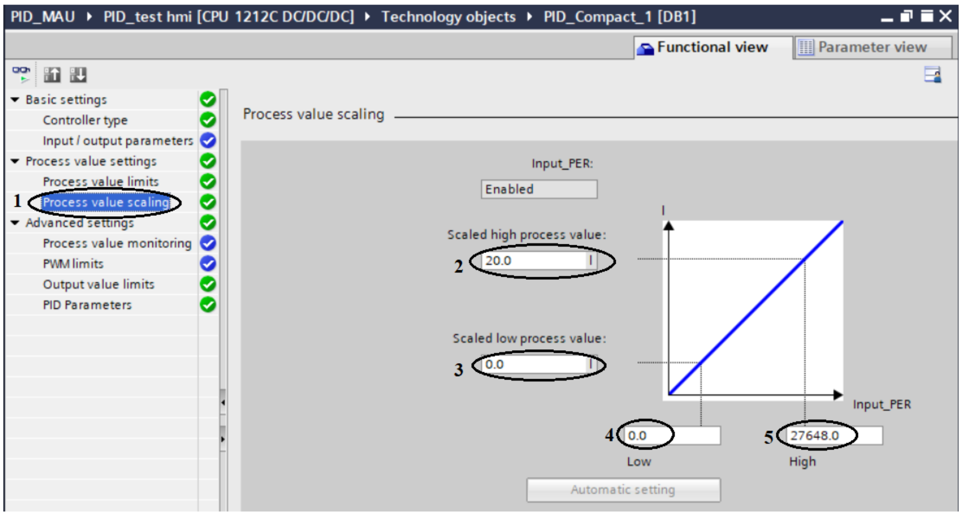
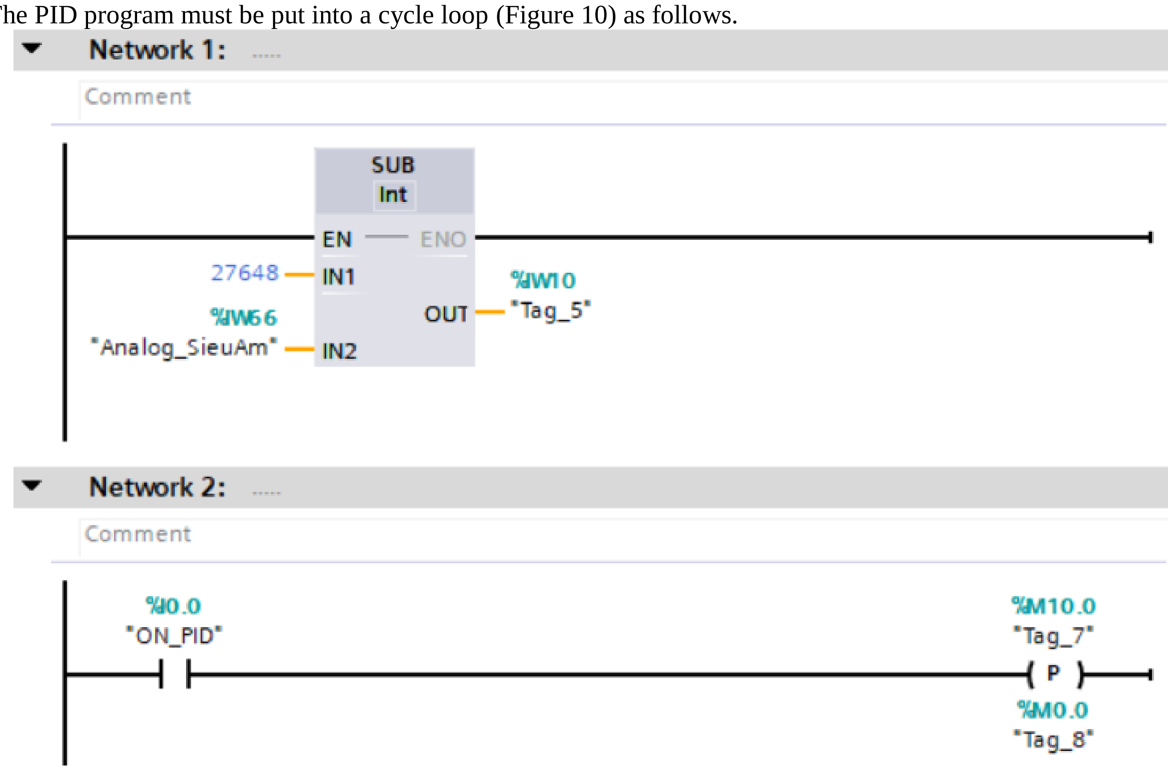


Figure 9: Set the volume ratio

Set volume based on input value. Because the control tank system has a maximum capacity of 20 liters, we configure the maximum control water level is 20 liters corresponding to the maximum value of Analog input signal is 10VDC (27648), the minimum capacity is 0 liters corresponds to 0VDC (Figure 9).

Implemention of the PID program

The PID program must be put into a cycle loop (Figure 10) as follows.



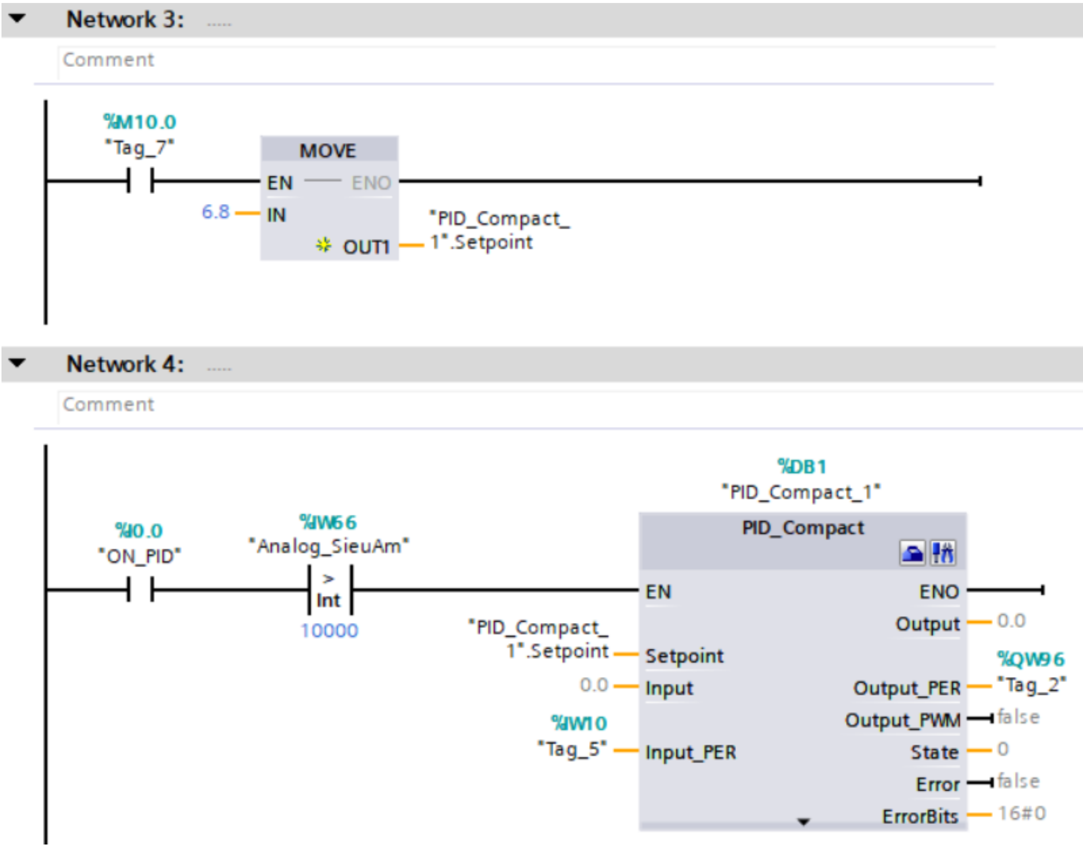


Figure 10: PID program

Detection of PID set parameters for real system

This step detects the optimal parameters for the real system. Perform by running Commissioning mode of the PID and conduct automatic parameter detection (perform steps from 1 to 4) as shown in Figure 11.

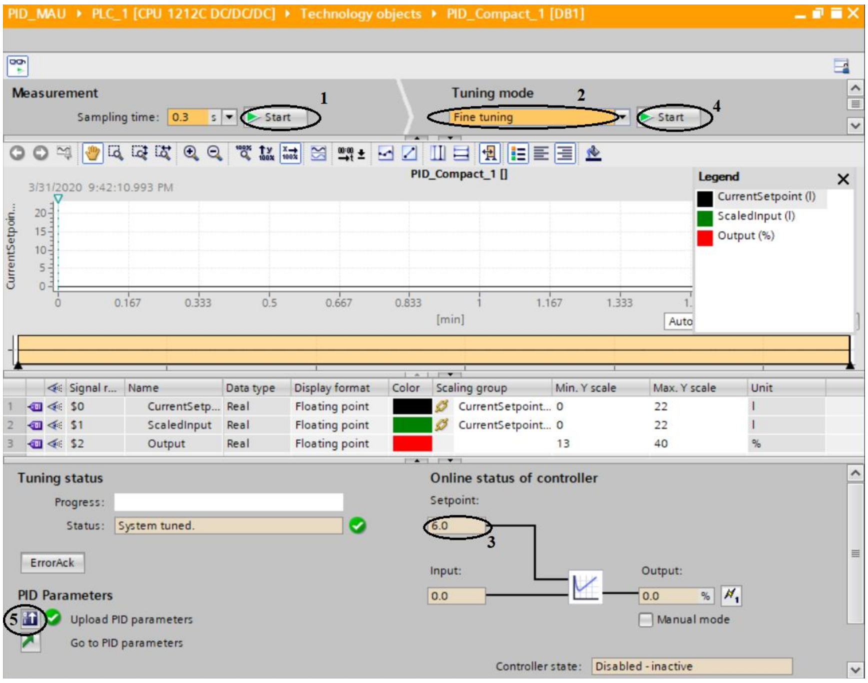


Figure 11: Detection of PID parameters

After PID detects parameters, we observe the response status chart, if we see the response graph as expected then we proceed to Upload PID parameter (step number 5). This step can be performed many times to get the optimal set of parameters

Operation of experimental models

The proposed experimental model performs the above steps. The system results respond well to control signals as shown in Figure 12.

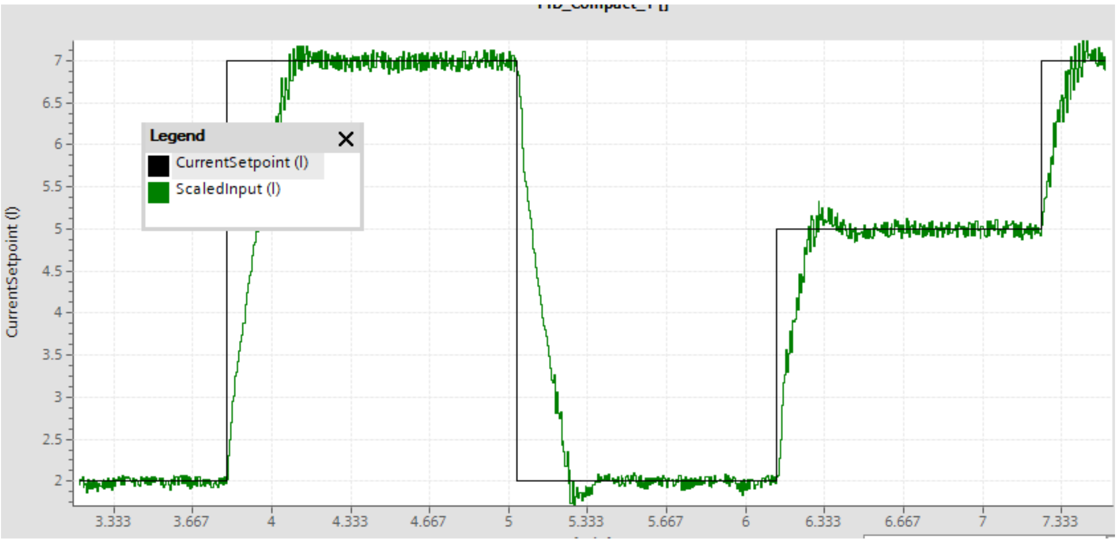


Figure 12: Experimental test of models

II. CONCLUSION

The article provides standardized steps to help readers build a system of water levels in the tank easily by applying the available industrial control devices to reduce the dependence on the high-tech work force. Experimental models are built to work well with the requirements. The PID controller parameters are detected automatically, reliably and quickly.

REFERENCES

[1]. Siemens S7-1200 Manual.
[2]. Robert L. Mott (2014). Applied Fluid Mechanics. Pearson.

Toan Pham Van. "Design of the Water Balance System in the Water Tank." *International Journal of Engineering Research and Applications (IJERA)*, vol.10 (09), 2020, pp 43-50.